The London School of Economics
and Political Science

Agriculture, development and structural change in reform-era China

Samuel Marden

A thesis submitted to the Department of Economics of the London School of Economics for the degree of Doctor of Philosophy. London, September 2015.

Declaration

I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

I declare that this thesis consists of approximately 60,000 words.

Abstract

Market based reforms to China's agricultural sector, between 1978 and 1984, marked the start of the reform era. The reforms were enormously successful, resulting in dramatic increases in both agricultural productivity and output. The first two chapters of this thesis are an empirical exploration of the consequences of the agricultural reforms for the growth of China's non-agricultural sector and the pattern of Chinese urbanisation. The third chapter uses the interaction between differential rural income growth and the One Child Policy, to shed light on how declining family size has fuelled the latent demand for sex selective abortion in China and beyond.

The first chapter explores the link between agricultural productivity and industrialisation in the context of reform era China. A classic literature argues that, at low levels of development, improvements in agricultural productivity can provide an important stimulus to the non-agricultural sector, however empirical evidence of this is limited. Using a natural experiment provided by China's agricultural reforms, I show that higher agricultural productivity growth had a substantial positive causal effect on non-agricultural output. I use the predictions of a simple two sector model, which nests the possibility of linkages through demand externalities, the supply of capital, and the supply of labour, to provide additional results indicating that the linkages I observe appear to be driven primarily by increases in the supply of capital.

In the second chapter, I ask how higher agricultural productivity affected China's urbanisation. In 1978, at the time of the reforms, more than 80% of China's population lived in the countryside. By 2011, fewer than 50% did. Whether agricultural productivity increases the pace of urbanisation is theoretically ambiguous, and depends on whether the effect of higher rural incomes is more than offset by the increased demand for urban goods. I show that increased agricultural productivity not only increased the pace of urbanisation between 1978 and 1995, it also affected the type of cities that formed. Higher agricultural productivity increased

the output of the urban service sector, at the expense of the tradable industrial sector. The results are consistent with a simple model where urbanisation and structural transformation are jointly determined.

In the third chapter, I use China as a setting to explore the hypothesis that the increase in male-female sex ratios observed in China, and many other parts of the world, over the past fifty years is, at least in part, driven by the demographic transition to smaller family sizes. Since 1979, the One Child Policy has imposed economic, and sometimes non-economic sanctions, for breaching proscribed fertility levels. The economic sanctions have meant that, within a class of households, the 1CP may have constrained the fertility of poor households more than rich ones. Using plausibly exogenous variation in household income, I show that richer, less constrained households, had higher fertility in the wake of the implementation of the One Child Policy. I then show that this increase in fertility is associated with a subsequent decline in sex selection. The decline in sex selection is roughly contemporaneous with the emergence of pre-natal ultrasound which dramatically reduced the costs of sex selective abortion. Together, the results suggest that China's dramatic decline in fertility in the 1970's, may have played an important role in fuelling the demand for sex selection from the mid 1980's onwards.

Acknowledgments

The completion of this thesis has led to the accumulation of enormous debts, to a great many people, that I will probably never be able to repay. First and foremost, I would like to thank my supervisor Robin Burgess, and advisor, Gerard Padró i Miquel, for their ongoing support, their patience and their insights, without which I would have been lost. I have also benefited immoderately from discussions with, and comments from, other faculty and colleagues in STICERD and throughout LSE. In particular, conversations with Tim Besley, Gharad Bryan, Jon de Quidt, Laura Derksen, Ben Faber, Thiemo Fetzer, Jason Garred and Kelly Zhang have all improved this thesis enormously.

Tremendous thanks are also due to the administrative staff at LSE, with special mention to Gisela Lafico, Mark Wilbor, Jane Dickson, Nic Warner and Joe Joannes, who have all made things easier than they should have been. Clare Miller at Durham University library has been an immense help with the data collection.

Last, but by no means least, my family and friends deserve special thanks for putting up with me with such grace and good humour throughout this long journey.

Financial support from the Economic and Social Research Council and the Royal Economic Society is gratefully acknowledged.

Contents

List of Tables

List of Figures

Chapter 1

The Agricultural Roots of Industrial Development: 'Forward Linkages' in Reform Era China

A classic literature argues that improvements in agricultural productivity result in higher non-agricultural output, particularly at low levels of development. The proposed mechanisms for these 'forward linkages' centre on increases in the supply of factors—usually labour or capital—or demand externalities in product markets. Regardless of the mechanism, the empirical evidence for substantial forward linkages from agriculture is limited. In this chapter, I show that in reform-era China there were substantial forward linkages. I exploit the fact that China's 1978-84 agricultural reforms were more beneficial to farmers with land suited to cash crops to provide plausibly exogenous variation in agricultural productivity. Then, using a newly digitised panel of economic data for 561 counties, I trace the growth of agricultural and non-agricultural output over forty years. Higher agricultural output was associated with significantly faster subsequent growth in non-agricultural output. I estimate 15 and 25 year elasticities of 1.2 and 0.8. I am able to identify these linkages because China is subject to substantial geographic capital and labour market frictions. These frictions limit the equalisation of prices across space and keep local shocks local.

I use the predictions of a simple two sector model, which nests the possibility of linkages through demand externalities and the supply of capital or labour, to provide evidence that the linkages identified were primarily due to higher agricultural surpluses increasing the supply of capital to local firms.

1.1 Introduction

The poorest countries economies are overwhelmingly agrarian, while those of rich countries are dominated by manufacturing and services. Perhaps because of agricultures initial preeminence, a classic literature has argued that agricultural development is either a prerequisite to industrial development, or that it carries important 'forward linkages' to other sectors of the economy (Rosenstein-Rodan, 1943; Schultz, 1953; Lewis, 1954; Rostow, 1960). This view has been influential with policymakers: the World Bank (2007, p.7) states that 'success stories of agriculture as the basis for growth at the beginning of the development process abound' citing England, Japan, India, Vietnam and China as prominent examples of agriculture led growth. In spite of this view, the empirical evidence linking improvements in agricultural productivity to any of these countries subsequent industrialisations is limited.

Agriculture has been argued to provide linkages to industry through several channels. The three most common are the classical ones. If agricultural productivity improvements reduce the demand for agricultural labour—and labour cannot migrate—the wage faced by non-agricultural firms will fall and non-agricultural output will increase through the *labour channel*. If agricultural productivity improvements increase rural savings—and capital is immobile—the rental rate faced by non-agricultural firms will fall and non-agricultural output will increase through the *capital channel*. If agricultural productivity improvements increase the demand for non-agricultural goods—and imports are not easily available—the price of non-agricultural goods will rise and non-agricultural output will increase through the *demand channel*.[1]

In each case, these linkages are only observable locally if there are impediments to the movement of either labour, capital or goods (as shown

[1] Linkages through the *labour* channel are considered in Bustos et al. (2014). The *demand channel* in particular is often highlighted in the macroeconomic structural transformation literature. See, in particular Ngai and Pissarides (2007), but also Murphy et al. (1989), Echevarria (1997), Kongsamut et al. (1997). Acemoglu and Guerrieri (2008) provide a model of structural change driven by capital accumulation.

by Matsuyama, 1992). Unfortunately, plausibly exogenous variation in agricultural productivity is more easily available at a sub-national level (where conditions often approximate those of a small open economy) than the cross-national level (where frictions are more widespread). Not surprisingly then, the best identified papers exploring linkages from agriculture to industry have focussed on relatively short run effects through local labour markets, while linkages via other channels remain under explored.[2]

In this chapter, I exploit a natural experiment provided by China's 1978-84 agricultural reforms, to show that improvements in agricultural productivity were an important contributory factor to China's subsequent non-agricultural output growth. A long panel of newly digitised county level data allows me to track the economic performance of 561 counties over more than forty years. The beneficial effects were long lasting: a 1% increase in post-reform agricultural output is associated with 1.2% and 0.8% higher non-agricultural output fifteen and twenty-five years later. This chapter thus provides quasi-experimental evidence of significant positive forward linkages between the agricultural and non-agricultural sectors in early reform era China. As a corollary, it also provides evidence that improvements in agricultural productivity can promote significant non-agricultural development for countries at the lowest levels of development. In providing this evidence, I benefit from several features of China's economy.

First, China's agricultural reforms provide a plausibly exogenous source of variation in agricultural productivity. Prior to the reforms, rural institutions strongly encouraged the planting of grain. Farming

[2]See especially, Foster and Rosenzweig (2004) and Bustos et al. (2014) who exploit sub-national variation in agricultural output in India and Brazil. These papers find that unless improvements in agricultural technology are labour saving—as in the case of the introduction of genetically modified soybeans in Bustos et al.—improvements in agricultural productivity crowd out the industrial sector. Hornbeck and Keskin (2015) also fail to find evidence of local economic spillovers to the non-agricultural sector in a developed country setting. This literature is also related to the literature on local resource windfalls (e.g. Caselli and Michaels (2013), who find very limited economic spillovers of oil windfalls in Brazil).

communes were forced to be self-sufficient in all foodstuffs, meet quotas for grain deliveries to the state, and faced political pressure to produce in excess of their quotas. Farming was also organised along communal lines, which adversely affected farmers incentives to maximise output. The reforms decommunalised agriculture and relaxed the constraints on the production of cash crops. So, while all farmers could benefit from the improved incentives provided by decommunalisation (McMillan et al., 1989; Lin, 1992), those with land suited to cash crops gained an additional benefit from the freedom to plant these crops. My empirical strategy exploits differences in the suitability of land for growing cash crops to provide variation in agricultural output growth.

Second, there were substantial geographic frictions preventing the free movement of labour and capital in China. The capital market frictions were primarily due to the Chinese financial system's institutional bias towards state owned enterprises (SOEs). In the reform era, soft loans at below market rates replaced direct budgetary support as the primary means of subsidising SOEs. In order to satisfy the capital requirements of SOEs, non-state firms access to the formal financial sector was curtailed. Non-state firms were instead forced to rely on capital raised from 'local' sources, such as the savings of family and friends, retained profits, and loans from local governments or rural credit cooperatives. Non-state firms reliance on local sources of capital meant that 'local money stay[ed] local' (Naughton, 2007, p.279) and restored the geographic link between savings and investment that is observed across countries but rarely across sub-national regions.[3] China also had a relatively immobile labour force during the 1980's and early 1990's. The *hukou* internal passport system increased the cost of migration (Chan and Zhang, 1999) and, relative to

[3]For evidence of capital market frictions across countries one can begin with the extensive literature beginning with Feldstein and Horioka (1980). For evidence of the absence of capital market frictions within countries in a similar vein see Sinn (1992) who looks at US States, Helliwell and McKitrick (1999) for Canadian Provinces, Paweenawat and Townsend (2009) for Thai villages and Dekle (1996); Iwamoto and Van Wincoop (2000) for Japan. China, of course, provides an exception in this literature: using a similar approach to the previous papers, Boyreau-Debray and Wei (2005) find evidence of substantial cross-province capital market frictions in China.

the size of the population, the number of migrant workers was low. These capital and labour market frictions make Chinese counties much closer to (small) countries than comparable administrative divisions elsewhere and allow the identification of linkages through both the *capital* and *labour channels*. However, although China may have had substantial internal barriers to trade at the province level (Young, 2000; Poncet, 2003), the barriers at the county level were probably less significant; I may not be able to identify linkages through the *demand channel*.

Third, in the years following the reforms, China was growing rapidly from a low base. China's growth in the 1980's thus provides an example of an economy in the early stages of industrialisation—precisely the stage of development that linkages from the agricultural sector have been been argued to be strongest. In a similar vein, at the onset of the reforms agriculture was a significant share of the Chinese economy, representing 71% of employment and 28% of output at the national level (and even more in the counties in my data).[4] The large size of the agricultural sector makes linkages to the non-agricultural sector both more economically important and easier to identify.

To guide the empirical analysis, and help understand how improvements in agricultural productivity led to higher non-agricultural output, I provide a simple two-sector model which allows for forward linkages through the *labour*, *capital* and *demand channels* described above. Increases in savings, investment and non-agricultural output are consistent with each of the channels, however, differences in other moments of the data are more revealing.

Because the benefits of agricultural reforms varied across space, the main empirical strategy used is difference-in-differences. I identify counties which are 'suited to cash crops' using high resolution data on theoretical crop yields from the Food and Agriculture Organisation's Global Agro-Ecological Zones database.[5] Counties are deemed suited to

[4] Aggregate figures (for 1978) obtained from the China Data Centre at the University of Michigan.

[5] The use of this data in this type of context was pioneered by Nunn and Qian (2011) who identified parts of Europe likely to benefit from the introduction of the potato after

cash crops if their productivity in cash crops is high relative to grain. I combine the agricultural productivity data with a newly digitised panel of economic data for 561 non-metropolitan counties in 8 provinces between 1965 and 2008. The relatively long panel allows consideration of both short and medium run effects. The large number of counties allows me to include a full set of county and province-by-time fixed effects, which flexibly control for preexisting differences across counties and differential trends by provinces. The inclusion of these fixed effects mean I exploit only within province variation—I am not comparing booming coastal China with the backwards interior. The empirical analysis has three parts.

First, I show that counties more suited to cash crops had faster post-reform growth in agricultural output. A 1 standard deviation increase in my measure of suitability is associated with around a 20% increase in post-reform agricultural output. This increase appears to be permanent, and is fairly constant from 1990 onwards, suggesting that improving the allocation of crops to land caused a one time increase in agricultural output. Back of the envelope calculations suggest that specialisation increased agricultural output by 9-15% between 1978-85 (or around one-sixth of the total increase). Although suitability for cash crops was associated with faster post-reform growth in agricultural output it was uncorrelated with pre-reform growth. Counties were following parallel trends. While I find large gains from specialisation, previous studies have not (Lin, 1992; Lin and James, 1995). The difference in findings may be due to the more disaggregated data used in this study. Indeed, if I repeat my analysis using only province level data—the level of aggregation used in previous studies—the gains from specialisation are neither economically nor statistically significant.[6] I also show that,

the Columbian exchange. More recently Bustos et al. (2014) has exploited this data to indicate which parts of Brazil stood to gain from the introduction of GM Mazie and Soy.

[6]The difference between aggregating at the county or province level is roughly equivalent to the difference between aggregating at the county or state level in the US. There are approximately 80 county level administrative divisions in the average Chinese province and around 60 counties in the average US state.

consistent with specialisation, counties suited to cash crops increased the physical share of cash crops in their output.

Second, I show that counties suited to cash crops also had faster post-reform growth in non-agricultural output. Using suitability for cash crops as an instrument for agricultural output, I estimate 15 and 25 year elasticities of 1.2 and 0.8. I also show that counties suited to cash crops had substantially faster post-reform growth in savings and investment. The growth of savings, investment and non-agricultural output were all uncorrelated with suitability for cash crops prior to the reform; as with agricultural output, counties were following parallel trends in each of these variables. These results suggest there were substantial forward linkages from agriculture in early reform era China.

Third, while the model makes clear that the behaviour of economic aggregates such as non-agricultural output, savings and investment will not in general reveal *how* higher agricultural productivity increased agricultural output, it does suggest other moments in the data that will be more revealing. Linkages through the *labour channel* entail a decline in the share of labour working in agriculture. But in the data, the share of labour in agriculture increases in counties suited to cash crops. Linkages through the *demand channel* are stronger in counties less open to trade in goods. But in the data, linkages are weaker in less open counties. Linkages through the *capital channel* imply that firms who lack access to national capital markets face cheaper capital and, in the data, non-state firms make factor choices as if they do have access to cheaper capital in counties suited to cash crops. (No such effect is observed for state owned firms which have access to the national banking system and hence do not need to raise capital locally.) The data are consistent with the institutional details: both suggest the linkages identified are primarily through the *capital channel*.

In China, higher agricultural surpluses led to higher savings, capital accumulation and, ultimately, non-agricultural output. However, cross country evidence suggests capital accumulation has little power to explain international income differences (Easterly and Levine, 2001;

Caselli, 2005). The empirical literature linking savings and growth is also inconclusive (Carroll and Weil, 1994; Attanasio et al., 2000; Aghion et al., 2006). On the other hand, decompositions of the growth of many of the fast growing Asian countries, including Japan, South Korea, Taiwan, Singapore and, of course, China do suggest an important role for capital accumulation (Kim and Lau, 1994; Young, 1995, 2003; Collins and Bosworth, 1996). This chapter provides additional support for the proposition that capital accumulation was an important factor in these countries growth. More enlightened policies were surely essential to these countries' industrialisation but, conditional on these policies, the accumulation of capital played an important role.

In another parallel to China, many these Asian countries also undertook successful agricultural reforms around time they began to industrialise. Post-war land reforms in Japan, South Korea and Taiwan redistributed land to peasants and are thought to have increased agricultural output (Dore, 1959; Thorbecke, 1979; Jeon and Kim, 2000). More recently, the decommunalisation of agriculture in Vietnam in the mid 1980's dramatically increased agricultural output (Pingali and Xuan, 1992) and raised the curtain for a sustained period of rapid growth that continues to this day. In each of these cases, increases in agricultural output due to the reforms could have increased the supply of capital to the non-agricultural sector—just as it did in China.

This chapter is most closely related to a small number of recent papers focussing on the effect of plausibly exogenous increases in agricultural output on the local economy. Foster and Rosenzweig (2004) and Bustos et al. (2014) explore the introduction of green revolution rice in India, and GM Maize and Soy in Brazil. Because capital and goods are able to flow relatively easily in India and Brazil, these papers focus on linkages through local labour markets, finding that only labour saving agricultural technology shocks (as in the case of Soybeans in Bustos et al.) result

in increases in agricultural output.[7] These papers together, and Bustos et al. in particular, suggest that improvements in agricultural productivity can lead to non-agricultural productivity growth and structural change—even in open economies—when the increases in productivity are labour saving. This chapter differs from these previous papers in several ways; by exploiting a setting which allows me to observe linkages through capital markets; by considering these linkages over a long time horizon; and importantly, by exploring linkages during at the earliest stages of development where they have been argued to be most important.

The remainder of the chapter proceeds as follows; section 1.2 presents a simple two-sector model of agricultural and non-agricultural output; section 1.3 provides institutional background to China's agricultural reforms and reform era credit and labour markets; section 1.4 outlines my empirical strategy and describes the data; section 1.5 provides results for the agricultural sector showing counties suited to cash crops benefitted disproportionately from the reforms; section 1.6 provides results showing that there were positive linkages between the agricultural and non-agricultural sectors, and that these linkages were primarily through the capital channel; section 1.7 concludes.

1.2 Conceptual Framework

To guide the subsequent analysis, I provide a simple two-sector model of production at the county level. The county is endowed with 1 unit of land and L units of labour. Both land and labour are homogenous, immobile and unchanging over time.

Each county also has a stock of savings, $S_t \geq 0$, which evolves according to

$$S_{t+1} = s(Y_t + (1 + r_t)S_t - (r_t + \delta)K_t) \tag{1.1}$$

[7] Hornbeck and Keskin (2015) perform a similar exercise exploiting a technological shock which provides access to groundwater in US Ogallalla aquifer under the United States Great Plains.

where r_t is the interest rate on savings, and $\delta \in (0, 1)$ is the depreciation rate. Savings in the next periods are a constant share $0 < s < 1$ of a counties current period stock of savings and and income (net of capital costs).[8]

Output, $y_t^j \geq 0$, is produced in agricultural and non agricultural sectors $j \in \{A, N\}$. Both sectors produce with constant returns to scale

$$y_t^A = \Psi_H f^A(\Psi_L L_t^A, \Psi_B B_t) \tag{1.2}$$

$$y_t^N = f^N(L_t^N, K_t) \tag{1.3}$$

where f^j are twice differentiable, strictly increasing, strictly concave productions functions with $f_2^N \to 0$ as $K_t \to \infty$, where f_2^N is the derivative of f^N with respect to its second argument. (The marginal product of capital approaches 0 in the limit.) Production requires strictly positive quantities of both factors so $f^j(0, \cdot) = 0$ and $f^j(\cdot, 0) = 0$. Note that while both sectors use labour L_t^j, only the agricultural sector uses land, B_t, and only the non-agricultural sector uses capital, K_t. I assume that the f^j's are such that labour is always used in both sectors if $K_t > 0$.

I consider Hicks-Neutral Ψ_H, labour augmenting Ψ_L and land augmenting Ψ_B agricultural technologies. I define an improvement in agricultural technology as 'labour saving' if, holding factors constant, it reduces the marginal product of labour, i.e.

$$\frac{\partial MPL_t}{\partial \Psi_q} = \frac{\partial}{\partial \Psi_q} \Psi_H \Psi_L f_1^A(\Psi_L L_t^A, \Psi_B B_t) < 0 \tag{1.4}$$

The conditions for an improvement in agricultural technology to be labour saving are quite specific. If the improvement in agricultural technology is labour augmenting, it is labour saving when the elasticity

[8] A savings function of this type can be a consequence of dynastic single period lived representative consumer with warm-glow preference $C_t^{1-s} S_{t+1}^s$ in the manner of Andreoni (1990). This type of preferences are used in Banerjee and Newman (1993) and many other models of growth.

of labour demand with respect to the wage is less than 1.[9] If agricultural technology is land augmenting, it is labour saving when land and labour are substitutes and $f_{12}^A(\Psi_L L_t^A, \Psi_B B_t) < 0$. Hicks-Neutral improvements in agricultural technology are never labour saving.

Each sector maximises periodic profits taking prices as given, and solves

$$\max_{L_t^j, K_t, B_t} = p_t^j y_t^j - w_t L_t^j - (r_t + \delta)K_t - z_t B_t \tag{1.5}$$

where p_t^j, w_t and z_t are output prices, wages and land rental rates. Market clearing in labour and land markets imply that

$$L = L_t^N + L_t^A \tag{1.6}$$

$$1 = B_t \tag{1.7}$$

The prices p_t^j and rental rates r_t depend on whether agricultural and non-agricultural output and/or capital are freely tradable. If they are, then prices are equal to the 'world' prices and $p_t^j = \tilde{p^j} \, \forall \, t$, j and/or $r_t = \tilde{r}$. To prevent the stock of capital growing without bound in an open economy, let $s(1 + \tilde{r}) < 1$.

If the county is closed to capital flows then the supply of capital is no longer perfectly elastic at rate $(r_t + \delta)$. Instead capital market clearing is given by

$$S_t = K_t \tag{1.8}$$

[9] To see this, note that we are holding B constant so the production function can be written as a function of just labour $\hat{f}^A(\Psi_L L)$. Defining $\hat{L} = \Psi_L L$, the first order conditions of the firms problem and implicit function theorem give labour demand as $\hat{L}^d(\frac{w}{\Psi_L})$. Using $L = \hat{L}^d/\Psi_L$ and noticing that $\frac{\partial \hat{L}^d}{\partial \Psi_L} = -\frac{w}{A}\frac{\partial \hat{L}^d}{\partial w}$, take derivatives and rearrange to obtain $\frac{\partial L}{\partial \Psi_L}\frac{\Psi_L}{L} = -(1 + \frac{\partial L}{\partial w}\frac{w}{L})$. This condition can also be stated in terms of f, in which case an improvement in labour augmenting agricultural technology is labour saving if $f_{11}^A(\Psi_L L_t^A, \Psi_B B_t)\Psi_L L_t^A + f_1^A(\Psi_L L_t^A, \Psi_B B_t) < 0$ i.e. if the production function is relatively concave.

If agricultural and non-agricultural output are not tradable, I instead assume they are inputs into the production of a tradable final good. (We can think of the final good as being used for capital and consumed.) This is a little bit artificial, but allows counties to service their external debt while still retaining the forces from closed economy models of demand led structural transformation. The final good is produced by a competitive final goods sector with constant returns to scale production function $g(y_t^A, y_t^N)$. Without loss of generality, assume that the final good sector is the numeraire sector. Whether agricultural and non-agricultural output are tradable or non-tradable, real output is $Y_t = p_t^A y_t^A + p_t^N y_t^N$.

If agricultural and non-agricultural output are perfect substitutes, then $g(y_t^A, y_t^N) = \eta^A y_t^A + \eta^N y_t^N$, and so if $\eta^j = \tilde{p}^j$, the economy is equivalent to one where agricultural and non-agricultural output are tradable. In this special case, the relative price of non-agricultural output is unaffected by agricultural productivity. To highlight the potential effects of the *demand channel*—which I presented as increasing the relative price of non-agricultural output—let us instead assume that that g is Leontief. Output of the final good is

$$Y_t = g(y_t^A, y_t^N) = \min\{\eta^A y_t^A, \eta^N y_t^N\} \tag{1.9}$$

with $\eta^j > 0$. Not surprisingly, in this setting increases in agricultural productivity will increase non-agricultural output.[10]

The comparative statics with respect to agricultural productivity thus depend on three factors. Whether the increase in agricultural productivity is labour saving; whether capital flows freely, and; whether agricultural and non-agricultural output are freely tradable.

As a baseline, I consider the comparative statics of a county which is open to flows of capital, trade in agricultural and non-agricultural output, and where the increase in agricultural technology is not labour saving.

[10]There are, of course, an intermediate set of production functions, where the effect on non-agricultural output depends on the substitutability between agricultural and non-agricultural output, but the relative price of non-agricultural output always increases.

This is the case of a small open economy and a 'normal' improvement in production technology—the conditions that probably apply in most studies of local agricultural productivity shocks.

In the baseline case, agricultural technology improvements always crowd out non-agricultural output. I then consider three additional cases where precisely one of the forward linkages discussed in the introduction are in effect. These additional cases highlight what increases in non-agricultural output due to the *labour*, *demand* and *capital channels* look like. These cases also highlight why exploiting subnational data can limit our ability to identify forward linkages from agriculture.

1.2.1 Comparative statics

I explore the effect of increases in agricultural technology on the steady state values of several variables. I define the steady-state as being reached when $S_t = S_{t+1} = S_{SS} \ \forall t \geq t_{SS}$. As there are no other dynamic considerations when this point is reached all other variables are also constant. All proofs are straightforward and provided in the appendices.

Comparative Statics 1 (Baseline)**.** *If $p_t^j = \tilde{p}^j \ \forall \, t, j$ (free trade in agricultural and non-agricultural output), $r_t = \tilde{r} \ \forall \, t$ (capital is perfectly mobile), and (1.4) does not hold (agricultural technology is not labour saving) then an improvement in agricultural technology Ψ_q has the following effects on the steady state*

(a) Agricultural output y^A, the share of labour in the agricultural sector L^A/L and savings S increase.

(b) The wage w and capital rental rate $r_t = \tilde{r}$ are unchanged.

(c) Non-agricultural output y^N, the share of labour in the non-agricultural sector, L^N/L, and capital employed K fall.

In the baseline case improvements in agricultural technology decrease the size of the non-agricultural sector for exactly the reasons outlined in Matsuyama (1992): the returns to working in the agricultural sector have increased. The comparative statics of the baseline case are consistent

with the findings of Foster and Rosenzweig (2004), who explore the consequences of improved yields in green revolution India. Despite this, in the empirics, I will show that improvements in agricultural technology were associated with increases in non-agricultural output which suggest that there were positive effects through one or more of the following channels.

Labour channel

To consider linkages through the *labour channel* assume improvements in agricultural technology are labour saving. As in the baseline, the county remains open to flows of capital and trade in agricultural and non-agricultural output.

Comparative Statics 2 (Labour Channel)**.** *If $p_t^j = \tilde{p}^j \ \forall\, t, j$ (free trade in agricultural and non-agricultural output), $r_t = \tilde{r} \ \forall\, t$ (capital is perfectly mobile), and (1.4) holds (agricultural technology is labour saving) then an improvement in agricultural technology Ψ_q has the following effects on the steady state*

(a) agricultural output y^A, non-agricultural output y^N, capital employed K and savings S increase;

(b) the wage w and capital rental rate $r_t = \tilde{r}$ are unchanged;

(c) the share of labour in the agricultural sector, L^A / L, falls.

When agricultural demand for labour declines, the non-agricultural sector expands and imports capital from elsewhere. The differential effects of labour saving and non-labour saving improvements in agricultural technology were explored empirically in Bustos et al. (2014) and their results are consistent with the differences between the baseline and *labour saving* comparative statics.

Demand Channel

To consider linkages through only the *demand channel*, let us consider an economy where capital flows freely and improvements in agricultural

technology are not labour saving. However, unlike in the baseline case, let the price of agricultural and non-agricultural output be determined locally by the demand of the local final goods sector. Agricultural and non-agricultural output are non-tradable.

Comparative Statics 3 (Demand Channel)**.** *If p_t^j are the equilibrium prices, where demand comes from a profit maximising and price taking final goods sector maximising $Y_t - p_t^A y_t^A - p_t^N y_t^N$ and the production function for Y_t is (1.9) (no trade in agricultural and non-agricultural output), $r_t = \tilde{r} \; \forall \; t$ (capital is perfectly mobile), and (1.4) does not hold (agricultural technology is not labour saving) then an improvement in agricultural technology Ψ_q has the following effects on the steady state*

(a) agricultural output y^A, non-agricultural output y^N, the price of non-agricultural output p^N, the wage w and capital K increase;

(b) the rental rate on capital $r_t = \tilde{r}$ is unchanged;

(c) the price of agricultural output p^A declines;

(d) the effect on the share of labour in the agricultural sector, L_A/L, is indeterminate.

Because agricultural and non-agricultural output are perfect complements in the production of the final good higher agricultural output increases the relative price of non-agricultural output and hence non-agricultural output itself. This is a version of the mechanism central to Ngai and Pissarides (2007). Related mechanisms are also considered in a large number of other papers in the macroeconomic structural transformation literature (see e.g. Matsuyama, 1992; Echevarria, 1997; Kongsamut et al., 1997). If counties are closed, higher agricultural output can increase non-agricultural output even in the absence of increases in the supply of capital and labour.

Capital Channel

To consider linkages through the *capital channel*, let us once again assume improvements in agricultural technology are not labour saving. However,

unlike in the baseline case let the county be closed to capital flows so that market clearing condition (1.8) holds.

Comparative Statics 4 (Capital Channel)**.** *If $p_t^j = \tilde{p}^j \ \forall\, t, j$ (free trade in agricultural and non-agricultural output), (1.8) holds (capital is immobile and accumulated locally), and (1.4) does not hold (agricultural technology is not labour saving) then an improvement in agricultural technology Ψ_q has the following effects on the steady state*

(a) capital utilised K, savings S and the wage w increase;

(b) the rental rate on capital falls r;

(c) the effect on non-agricultural output y^N and the share of labour in the agricultural sector L_A/L is indeterminate.

For non-agricultural output there are two offsetting effects: competition for labour from the agricultural sector reduces non-agricultural output, but higher savings increase the supply of capital. If the second effect dominates then non-agricultural output increases.

1.2.2 Empirically disentangling the channels

The empirical results will show that higher agricultural output resulted in higher non-agricultural output. The model suggests two approaches to identifying whether the increase was primarily through the *labour*, *capital* or *demand channels*.

First, a careful evaluation of capital market institutions, internal barriers to trade and the nature of the agricultural productivity shock, will be indicative. If capital or goods are able to flow freely across county lines, we are unlikely to observe linkages through the *capital* or *demand channels*. If the increase in agricultural technology—here the ability to specialise in cash crops—seems likely to increase the demand for labour, we are unlikely to observe linkages through the *labour channel*.

Second, we can use differences in the comparative statics to suggest informative tests. While, increases in non-agricultural output, savings

and investment are consistent with any of the channels, other moments in the data may be revealing. In particular:

1. Linkages through the *labour supply channel* reduce the share of labour in agriculture;

2. Linkages through the *demand channel* have stronger effects on non-agricultural output in more closed places;

3. Linkages through the *capital channel* result in cheaper capital.

In section 1.6, I provide empirical results based on these moments which suggest increases in non-agricultural output were primarily through the *capital channel*. These results will be reinforced by the institutional details provided in the next section.

1.3 Institutional Background

In this section, I provide a brief overview of Chinese agricultural institutions in the run up to, and aftermath of, China's 1978-84 agricultural reforms. I will also discuss the extent to which capital and labour market institutions restricted factor mobility and whether specialising in cash crops was likely to have been labour saving. I conclude by outlining some of the most important reforms to the non-agricultural sector.

1.3.1 Rural institutions and agricultural reform

During the cultural revolution (1966-78), and to a greater or lesser extent from the mid 1950's onwards, Chinese agricultural institutions were characterised by four principal distortions.[11]

First, all land was state-owned and agricultural production was organised collectively via the commune system. Most land was farmed

[11] What follows draws on the large existing literature on Chinese agriculture. In particular Lardy (1983), Perkins (1988), Sicular (1988), Oi (1991), Lin (1992) and Huang (1998).

by 'production teams' of 20-30 households. Peasants were primarily paid for their contribution to agricultural production in grain rations although some cash was also distributed. The specifics vary, but typically around 60-70 percent of the grain allocation was distributed according to 'basic need' based upon factors such as household size. The remaining grain, and any cash, was distributed according to work points which tended to be allocated according to days worked and type of job. As a result, incentives to provide effort on communal lands were very weak. It is perhaps telling that during the 1960's, yields on 'private plots'—where the farming household was the residual claimant—were twice as high as those achieved on communal farms (Burki, 1969).

Second, the state pursued a policy of grain self-sufficiency. From 1965, 'rural areas were still allowed to produce economic crops or raise animals, but only after they had achieved basic self-sufficiency in food grains' (Lardy, 1983, p. 49). Self-sufficiency was enforced by a state monopoly on trade in agricultural produce, which prevented rural households from purchasing grain. One manifestation of this policy was that inter-provincial trade in grain effectively ceased, with the share of (non-exported) grain traded across provincial lines falling from 3.4% in the 1950's to 0.1% by 1978 (Lardy, 1983, p. 51).

Third, the state further promoted grain production by encouraging payments of agricultural taxes in grain, providing most counties with quotas for grain deliveries and linking the political success of rural party cadres to the production of grain.

Finally, prices for agricultural goods were kept low to facilitate the transfer of surplus from the rural agricultural sector to the state industrial sector. Low prices further reduced the incentive for agricultural production beyond peasants' immediate needs.

Following the death of Mao in 1976, and the ascent of Deng Xiaoping's more economically liberal government in 1978, China began its long process of Reform and Opening Up. The agricultural sector was the first to undergo substantial reforms. Lin (1992) describes three main channels of reform: (1) the communal system was phased out

and replaced with the Household Responsibility System (HRS) under which households were assigned plots of land to farm for periods of up to 15 years and made the residual claimant on surplus output; (2) markets for agricultural goods were (somewhat) liberalised, rural periodic markets were reinstated, grain procurement quotas reduced in some areas and self-sufficiency policies relaxed; and (3) price reform—to stimulate production, state procurement prices for agricultural goods were raised substantially and the bonus for above quota deliveries was increased.

In response to the reforms, agricultural output growth increased dramatically. Output of grain increased by 5 percent per-year from 1978-85 compared to 2.4 percent per-year between 1952 and 1978. Output of cash crops increased even more rapidly: cotton by 19.2 percent per-year, sugar by 12.3 percent and oil-crops by 14.8 percent, compared to 2, 4.5 and 0.8 percent per year pre-reform. Despite the large relative increase in the production of cash crops there was little change in their relative price (see table 1.1). Consequently, in addition to benefiting from HRS, farmers with land suitable for growing cash crops may have enjoyed large windfalls from specialising in their production.

Planting cash crops instead of grain was, however, unlikely to have been labour saving. Taylor (1988) calculates labour utilisation per hectare (in China) for various crops in 1978 and 1985. He finds that utilisation is similar for grains and oilseeds but somewhat higher for cotton. As switching to cash crops thus probably increased the agricultural demand for labour, non-agricultural output is unlikely to have increased through the *labour channel*.

1.3.2 Capital market frictions

China's financial sector, which is dominated by the state owned banking system, has been distorted by its bias towards state owned firms. From the early 1980's onwards, soft loans largely replaced the direct budgetary support that state-owned enterprises previously enjoyed. These loans

Table 1.1: Selected Price and Yield Indices (1978=1)

	1965	1970	1978	1985	1990	1995	2000
	Grain Purchasing Prices						
Rice	0.87	0.99	1.00	1.67	2.92	6.32	
Wheat	0.87	1.00	1.00	1.71	2.39	5.28	
Maize	0.84	1.00	1.00	1.72	2.78	6.75	
Soybeans	0.62	0.73	1.00	2.55	4.17	7.91	
	Cash Crop Purchasing Prices						
Oilseeds	0.77	0.77	1.00	1.58	2.54	4.68	
Cotton	0.80	0.89	1.00	1.53	2.74	6.27	
	Aggregate Price Indices						
RPI	1.02	0.97	1.00	1.28	2.07	3.97	4.34
Agricultural Output	0.89	0.93	1.00	1.67	2.73	5.28	
Rural Industrial Products		1.02	1.00	1.11			
	Yield Indices: India						
Average Grain Crops	0.69	0.79	1.00	1.13	1.31	1.42	1.53
Average Cash Crops	0.83	0.89	1.00	1.16	1.42	1.48	1.39
	Yield Indices: USA						
Average Grain Crops	0.87	0.94	1.00	1.11	1.15	1.25	1.36
Average Cash Crops	0.83	0.88	1.00	1.16	1.12	1.12	1.17

Source for Prices: China Statistical Yearbooks, except Rural Industrial Products from Lin (1992).
Source for Yields: Three year moving average yield indices calculated from FAOSTAT data. Cash Crops a simple average of indices of cotton, groundnuts and rapeseed (not USA) indices. Grains a simple average of rice, wheat, maize and soybean yields.

were provided at below market rates. In order to satisfy the state owned sectors demand for capital, non-state firms were largely excluded from China's formal financial markets (Lardy, 1998; Brandt and Zhu, 2000; Huang, 2003).

The consequences of this financial favouritism can be directly observed by comparing the return on capital earned by state and non-state firms. For most years since 1978, Brandt and Zhu (2010) find a wedge between the return to capital in the state owned and non-state owned sector of more that 40 *percentage points*. Similarly, Dollar and Wei (2007) present survey data from 2001 and 2002, indicating that the return on capital is decreasing in the state's ownership share, and that collective and private enterprises have returns on capital approximately 45 percentage points higher than state owned enterprises.

Excluded from the formal banking system, non-state firms turned to other sources of capital. Compared to state owned firms, non-state firms were much more reliant on sources of capital that were raised locally. Retained profits, loans from local government (who also faced hard budget constraints), and the savings of family and friends were particularly important (Byrd and Lin, 1990; Oi, 1999; Allen et al., 2005). Even when non-state firms were able to access bank loans, these were usually provided by Rural Credit Cooperatives, which raised and provided capital over a limited geographic area and were 'poorly integrated into financial markets' (Park and Sehrt, 2001, p. 3) resulting in 'local money stay[ing] local' (Naughton, 2007, p. 279). Despite this low level of integration, Rural Credit Cooperatives were important financial institutions in rural areas. In 1995, they captured more than 60% of rural households savings deposits and 85% of their loans were made to households or rural enterprises (survey evidence in Brandt et al., 1997) so increases in rural savings play a potentially important role in expanding rural credit.

Perhaps as a consequence of these frictions, China appears to be subject to substantial geographic capital market frictions. Estimated returns on capital differ enormously between the regions, provinces and

Figure 1.1: Capital Mobility 1952-2010: after the reforms there were substantial capital market frictions (estimated Feldstein-Horioka coefficients)

cities of China (Bai et al., 2006; Dollar and Wei, 2007), suggesting that capital markets are unable to equalise the return on capital across space. In a similar vein, Boyreau-Debray and Wei (2005) show that there is *less* consumption risk sharing between Chinese provinces than between OECD countries. Boyreau-Debray and Wei also show that China fails the Feldstein and Horioka (1980) (FH) test of capital market integration: changes in provincial savings are highly correlated with investment.

In figure 1.1 I include the results of my own FH regressions, which estimate coefficients and associated 95% confidence intervals for each year between 1952-2010.[12] A coefficient of 0 indicates perfect capital

[12]Recall that the original FH regression was $i_v = \alpha + \beta s_v + \epsilon_v$ where i_v and s_v were the investment and savings share of GDP in province v respectively. I have estimated this on panel data with a full set of individual and time fixed effects i.e. $i_{vt} = \alpha_v + \delta_t + \sum_{t=1952}^{2010} \beta_t (s_{vt} \times I_t) + \varepsilon_{vt}$. For comparability with Boyreau-Debray and Wei (2005), and to ensure balance, I exclude Jianxi, Guangdong, Hainan, Sichuan, Chongqing, Ningxia and Tibet. Only the exclusion of Tibet materially changes the results and this is due to a huge increase in the Investment share of Tibetan GDP in the 2000's (up to above 100%

mobility while a coefficient of 1 indicates complete immobility. Unlike Boyreau-Debray and Wei, I do not find evidence of substantial frictions prior to the reforms.[13] However, after the reforms there are strong geographic frictions. The apparent post-reform increase in immobility is perhaps not surprising. Prior to the reforms, almost all investment was done by state-owned firms which had access to the banking system, state funds, and were subject to the whims of national development strategy. Consequently there were few barriers to capital mobility. After the reforms, an increasing share of investment was undertaken by non-state firms which were shut out of the formal financial sector and, as I have argued, had to rely on more local sources of capital.

These types of frictions have been invoked to explain several unusual features of the Chinese economy. Song et al. (2011) argues that the bias of the financial sector towards SOE's can explain the apparent paradox of high external savings in the face of high domestic returns on capital. Banerjee et al. (2012) suggest that their findings on the role of transportation infrastructure in China are supportive of a model where capital (and labour) are less mobile than goods. Finally, the findings of this chapter—that rapid growth in agricultural output resulted in faster local growth in non-agricultural output, higher savings, higher investment and higher ratios of capital to labour (but only in the non-state sector)—are hard to explain in the absence of geographic capital market frictions.

In having substantial internal geographic capital market frictions, the regions of China are much more like countries than comparable regions elsewhere. A large body of work in international macroeconomics rejects cross-border capital market integration across countries, but cannot usu-

of provincial GDP). Standard errors are clustered at the province level. Note, technically my measure of saving from the national accounts is incorrect as it doesn't include fiscal transfers, however fiscal transfers in China are extremely small relative to other countries (Wang and Herd, 2013) so their exclusion ought not to be too problematic.

[13]This is because my inclusion of time fixed effects control for national trends more flexibly than their controls. I can replicate their analysis almost exactly (modulo data revisions) and show that their results disappear with the inclusion of a full set of time fixed effects.

ally do so subnationally. For instance, capital mobility is almost always rejected by variants of the FH test described above when applied across countries. However, when the FH is applied within countries—anywhere other than China—the results are universally consistent with financial market integration.[14] Chinese capital market frictions thus provide a unique opportunity to explore the role of savings and investment using subnational variation.

1.3.3 Labour mobility and the *hukou* system

There were also restrictions on labour mobility for much of the PRC era. Because planners had prioritised urban industrial development and favoured urban residents—guaranteeing jobs, housing, public services and food—large imbalances between rural and urban living standards emerged. To prevent more migration to cities than could be absorbed, the *hukou* 'internal passport' system was developed.[15] The *hukou* provided each Chinese citizen with a place of registration and a classification as either 'agricultural' or 'non-agricultural'. Until 1998, children inherited their mothers *hukou* classification. Changing *hukou* status was difficult and costly, although easier for workers with university degrees and in demand skills. Reforms beginning in the late 1980's and continuing through the 1990's, such as the introduction of the 'blue' temporary urban *hukou*, somewhat liberalised migration but substantial barriers remained (Chan and Zhang, 1999).

The *hukou* system was enforced by tying access to public goods to place of registration. For urban residents this meant retirement benefits, health care, education, subsidised housing and access to jobs in state-owned enterprises; while for rural residents this principally meant the entitlement to farmland. In addition to public goods, *hukou* status

[14]See e.g. Sinn (1992) who looks at US States, Helliwell and McKitrick (1999) for Canadian Provinces, Paweenawat and Townsend (2009) for Thai villages and Dekle (1996); Iwamoto and Van Wincoop (2000) for Japan.

[15]See Cheng and Selden (1994) for a complete description of the origins of the *hukou* system and Chan and Zhang (1999) for a discussion of its reform in the 1990's.

determined access to state provided goods, at least until the end of rationing in 1993. Citizens with urban *hukou*'s were entitled to purchase staple goods such as grain, cooking oil, meat and sugar; whereas holders of rural *hukou*'s were expected to provide for themselves. Obtaining these goods outside the ration system was expensive, greatly increasing the cost of migration for the rural population.

As a result, the number of migrants in China was low. In the 1% sample of the 1990 population census, just 3.3% of the population lived in a different county to where they had five years previously. The comparable figure for the US is 25%, while in India 2.7% of the population move district *each year* despite Indian districts being significantly larger than counties.[16] These low figures are not an artefact of the procedures used to collect China's census data. A retrospective survey conducted by De Brauw et al. (2002) finds that just 4% of the rural labour force were migrant workers in 1981, this increased to a little below 6% by 1990, 10% by 1995 and almost 16% in 2000. In the years following the reforms, migration was very low, although it increased during the 1990's, and so may be of concern later in my sample period. In the results, I will thus be careful to show that there was little differential migration or population growth in areas suited to cash crops, as well as verifying that the results are robust to directly controlling for population growth.

1.3.4 The non-agricultural sector in the reform era

Agriculture was not the only sector to undergo substantial reforms. From 1978 onwards, restriction on the activities of the non-state sector were progressively lifted as China's economy became more market oriented. As this chapter focusses on linkages between agriculture and the rest of the economy, any linkages observed must be understood in the context of the reforms to the non-agricultural sector. My results will indicate that

[16] Figures from the US from 1980 and 1985 Current Population Survey available through IPUMS. More recent rounds of the CPS do not separate moves across county lines from moves within counties and are thus not comparable. Figures from India from the 64th round of the National Sample Survey (2007).

the linkages I observe were primarily due to an increase in the supply of capital to the non-state sector. As the reforms to the non-agricultural sector increased the productivity of this sector substantially, these reforms most likely increased the value of additional rural savings and hence the strength of the linkages.

While the possible complementarity between agricultural and non-agricultural reforms provide important contextual background for interpreting the size of the linkages uncovered, the presence of non-agricultural reforms also constitute a potential confounding factor for my empirical strategy (which, as will be discussed below, compares counties more or less suited to cash crops). If non-agricultural reforms were also more beneficial to counties relatively suited to cash crops, then my results will overstate the strength of the linkages from the agricultural sector.[17] It is thus worth briefly outlining the main pillars of reforms to the non-agricultural sector. As in my results linkages are clearly observable by 1990, I focus on the first stage of the reforms between 1979-92.

Prior to the reforms, China was a planned economy in which state owned enterprises played a dominant role. The state had a monopoly in many sectors of the economy. From 1979, some sectors were opened up to 'non-state' firms, with agricultural processing being an important early example. Large numbers of non-state firms entered the newly opened sectors, many of which were local collective enterprises (although there is some debate over just how 'collective' these firms were, e.g. Huang 2008). Regardless of the extent to which these firms were collective, they were broadly profit maximising and subject to hard budget constraints (Oi, 1999). Because industrial output was initially low, prices were substantially above marginal cost in the early days of reform and profits were high.

[17] Note, that this is in fact two threats: (1) non-agricultural reforms could have been more beneficial to counties with some characteristic correlated with suitability for cash crops, e.g. initial population density or education levels, (2) that growing cash crops was somehow directly beneficial to the growth of the non-agricultural sector through a channel other than *labour*, *capital* or *demand*.

While agricultural reforms allowed non-state firms access to agricultural inputs and their derivatives, the planning system restricted access to many intermediate goods which limited the growth of the non-state sector in the early days. The introduction of the 'dual-track' system from 1984 alleviated this problem (Naughton, 1996). The dual track system meant that state firms retained rights to allocations of resources at low government prices (and the accompanying responsibility to deliver a certain quantity of output at low government prices) but were allowed to produce 'off-plan' at market prices for inputs and outputs. This meant that (a) for many state owned firms, marginal production decisions were taken at market prices, and (b), that non-state firms could access inputs from strategic sectors reserved for state owned firms. Furthermore, because quotas and resource allocations for SOE's were fixed (in absolute terms) from 1984-87, and declined thereafter to almost nothing by 1995. The share of output directly planned by the state declined dramatically (Naughton, 2007, Fig. 4.1).

The consequences of these reforms, in partnership with reforms to the agricultural sector, were dramatic. The real industrial output of non-State firms increased by 15.6% per year between 1978-90 while the output of the state owned sector grew at 7.6% per year. However despite the rapid growth of the non-state sector, state-owned firms produced the majority of Chinese industrial output until 1998.[18]

1.4 Empirical Strategy and Data

In the previous section, I argued that China's agricultural reforms were likely to have disproportionately benefited counties with land suitable for growing cash crops. Thus, the principal empirical strategy used is difference-in-differences with 'suitability for cash crops' as a continuous

[18] Authors calculations based on University of Michigan China Data Centre aggregate output data.

treatment variable. My estimating equation is

$$Y_{ivt} = \alpha_i + \delta_{vt} + \beta_1(SCC_i^N \times D1985_t) + \beta_2(SCC_i^N \times Post85_t) + \varepsilon_{ivt} \quad (1.10)$$

where α_i and δ_{vt} are county and province-by-time fixed effects respectively. $D1985_t$ and $Post85_t$ are dummy variables taking values of one in 1985 or all years after 1985 respectively. Thus β_1 provides the short run effect of suitability for cash crops on my outcome and β_2 the medium run. SCC_i^N is my (normalised) measure of suitability for cash crops, the construction of which is described below. Y_{ivt} is an outcome of interest. In most specifications, I use the two-way cluster robust errors of Cameron et al. (2011) and cluster the standard errors at the prefecture and province-time levels.[19] This allows for autocorrelation of errors over time and space amongst immediate neighbours, and over space for counties in the same province while also providing a sufficient number of clusters to obtain reliable standard errors.[20]

The inclusion of individual fixed effects control for any time invariant characteristics of counties. Province-by-time fixed effects flexibly control for province specific shocks, including but not limited to, provincial polices, prices and economic performance. The inclusion of these fixed effects mean that I identify the post-reform benefit of suitability for cash crops using only within province variation; I am not comparing counties in booming Zhejiang to those in dusty Gansu. Thus, my identification assumption is: in the absence of the agricultural reforms,

[19]The prefecture is the administrative unit between the county and the province, on average a prefecture contains 7-8 counties and a province contains an average of 10 prefectures. The 'physical share of crops' regressions in section 1.5.2 are clustered at the county level due to the smaller sample size and corresponding reduction in number of clusters. Regressions on firm entry, firm factor utilisation and agricultural employment shares are clustered at the provincial level as data is available for the whole of China.

[20]Given the dataset, I believe that this is the 'correct' level to cluster at. However, the statistical significance of the results does not rely on clustering at this level. Clustering at lower levels, or along a single dimension, results in smaller standard errors (as is usual) and so the reported errors are in some sense conservative. Similarly, the use of errors with the spatial error correlation specified à la Conley (1999) also result in smaller errors two-way clustered errors employed here.

within a province, the growth in my outcomes of interest would have been uncorrelated with suitability for cash crops.

I provide several pieces of evidence in support of this parallel trends assumption. First, I use a specification including interactions of my treatment with each year in my data to show that the growth of each of my outcomes of interest was uncorrelated with suitability for cash crops prior to the reforms

$$Y_{ivt} = \alpha_i + \delta_{vt} + \sum_{s \neq 1978} \beta_s \left(SCC_i^N \times I_s \right) + \nu_{ivt} \tag{1.11}$$

In this specification, if the parallel trends assumption held prior to reform then $\beta_s = 0 \; \forall \, s < 1978$. Second, I show that my estimates are stable in the face of alternative fixed effect specifications which, for instance, indicates that any unobserved confounding factors are correlated with suitability in the same way within provinces as across provinces. Third, I show that my results are robust to the inclusion of county specific time trends. These time trends flexibly control for differential log-linear growth rates by county. Fourth, I show that my results are robust to controlling for a wide range of preexisting geographic and economic characteristics, as well as the placement of Special Economic Zones. Finally, I show that the results are robust to the omission of any of the provinces in my data, and to alternative ways of calculating my measure of suitability for cash crops. For brevity, the results of many of these robustness checks are contained in the Appendices.

1.4.1 Suitability for cash crops

The key variable for the empirical analysis is a measure of a counties suitability for cash crops. In the model presented in section 1.2, the freedom to plant cash crops would enter the production function as a change in one or more of the productivity parameters. I will construct a measure of suitability using the Food and Agriculture Organisation's Global Agro-Ecological Zones (GAEZ) which provides

theoretical estimates of gross physical output per hectare under optimal growing conditions at a high spatial resolution.[21] Although it is not clear precisely how the GAEZ productivities map into the agricultural production function, it is perhaps most appealing to think of them as Hicks-Neutral productivity shifters. In this case, farmers will want to switch to cash crops when the (price weighted) yield of cash crops is greater than that of grain, and the benefits of switching will be increasing in the difference in productivities.

Thus as a proxy for the gains from specialising in cash crops, I define suitability for cash crops in location ι as the ratio of the (price weighted) yield of cash crops to that of grain

$$SCC_\iota = \frac{\max\{\hat{\Psi}_{c\iota} p_c\}_{c \in \mathbb{C}}}{\max\{\hat{\Psi}_{c\iota} p_c\}_{c \in \mathbb{G}}} \tag{1.12}$$

where p_c is the price of crop c, $\hat{\Psi}$ is the GAEZ predicted yield and $\mathbb{C}$ and $\mathbb{G}$ are the set of cash crops and grains respectively.

I obtain prices from Sicular (1988) who provides government prices for a range of crops during the cultural revolution and the early reform era. For most crops Sicular provides two prices, a low 'below quota' price for deliveries of crops that were required by the central government and a higher 'above quota' price which applied to deliveries in excess of those mandated. In my baseline results, I use the 'above quota' price as this is the marginal price faced by farmers where quotas were non-binding, however, the results are robust to the use of below quota prices instead. In my main results I use prices from 1978 which have the virtue of preceding the change in agricultural output which followed the reforms. However, there is little pre or post-reform change in the relative price of cash crops and grains (see table 1.1), so it is not surprising that the results are also robust to the use of prices from years other than 1978.

[21] There are 138'000 cells in China. In Beijing a cell represents an area about 6.5km square, cells are larger towards the equator, so in Shanghai a cell is approximately 8km square. All except two counties in China—and all the counties in my data—contain the midpoint of at least one cell, and counties at the 5th, 50th, and 95th percentile contain 6, 27 and 199 cells respectively.

Productivities $\hat{\Psi}_{cl}$ are obtained from the GAEZ database.[22] The GAEZ data provide agricultural productivities for a number of crops at a high spatial resolution. The productivities are based on agronomic models which give measures of potential crop yield based on climatic conditions, soil type, elevation and gradient.[23] One advantage of a model-based measure of agricultural productivity is that, unlike directly observed yields, the productivities at a given location are exogenous to other economic activity. Along with the geographic and climatic conditions, the inputs of farmers, such as labour, fertiliser and irrigation, will also affect agricultural yields. In light of this, the GAEZ database includes productivities based on various scenarios for intensity of inputs and use of irrigation. As irrigation is widespread in China, I use the productivities based on 'intermediate inputs' and 'irrigation', however my results are robust to the use of other scenarios (see appendix table A.7). Figure 3.2 is a map depicting land suitability to cash crops for the whole of China; significant variation exists both across and, crucially for my empirical strategy, within provinces.

Following Lin and James (1995), I restrict the set of cash crops to cotton and oilseeds. These are the the most important non-grain crops in China and, along with grains, these crops account for at least 80% of planted area in the early reform era. The specific set of oilseeds and grains that I can consider is determined by the availability of the soil productivity and price data described above. The grains used are $\mathbb{G} = \{\text{Wheat, Rice, Maize, Soybeans}\}$ and the cash crops are $\mathbb{C} = \{\text{Rapeseed, Groundnut, Cotton}\}$.[24]

[22]The GAEZ data has been used in a number of studies in economics, including the Costinot and Donaldson (2014) study of the gains from agricultural market integration in the US and the Nunn and Qian (2011) study of the effect of the potato on population densities in Europe.

[23]The GAEZ yields are based on the 'dry' weight of crops obtained i.e. shelled peanuts, cotton lint, dried grains etc. Conversely, the Chinese price and output data relates mostly to wet yields. Consequently, other than for peanuts where the prices I have are for shelled peanuts, I convert the GAEZ productivities from 'dry' to 'wet' using the conversion factors supplied in the documentation (Fischer et al., 2012, p. 98).

[24]In the Chinese agricultural data, soybeans are classified as a grain and were thus subject to the same quotas and encouragement as other grains. However, classifying

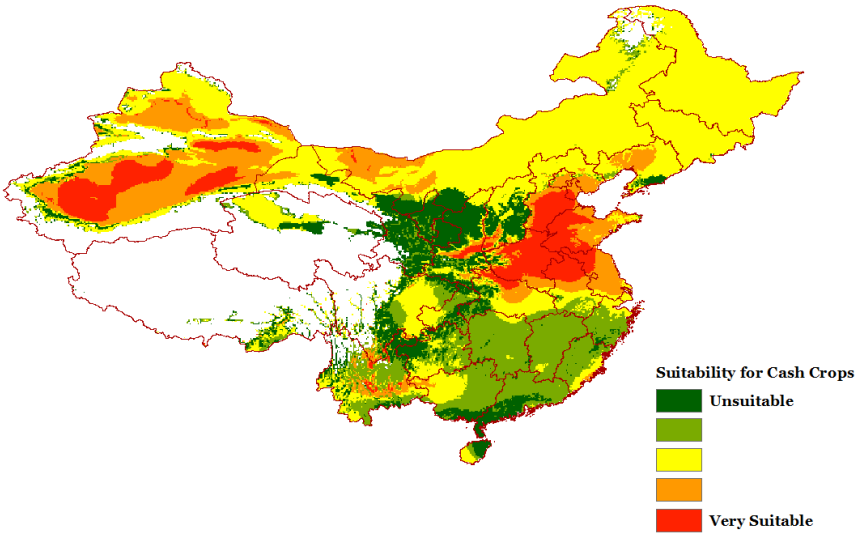


Figure 1.2: Suitability for Cash Crops

The above procedure provides a measure of suitability at the gridcell level, while my economic data is at the county level. To link the GAEZ data to the economic data, I use the ACASIAN Data Centre's geo-referenced county level administrative boundaries for all of China's 2341 counties in 1999. The suitability of a county is calculated as the simple average across all cell midpoints within the county $SCC_i = n_i^{-1} \sum_{\iota \in i} SCC_\iota$ where n_i is the number of fertile cell midpoints in county i.

In section 1.5.2, I will use measures of suitability specifically for cotton and oilseeds, rather than for cash crops generally. The construction of each of these variables is directly analogous to my main measure, but using only the appropriate subset of $\mathbb{C}$.

soybeans as an cash crop does not significantly affect my results. There are a number of less widely grown 'grains' (sorghum, millet and potatoes) and an oilseed (sesame) that are omitted because I lack data on prices and/or productivities. These omitted grains and oilseeds constitute around 10% of total grain and oilseed planted areas in China as a whole, but less in the counties for which I have data, as the planting of sorghum, millet and sesame is concentrated in Southern China, where my data has limited coverage.

1.4.2 Economic data

County-level economic data on economic aggregates are primarily drawn from the set of Anniversary Yearbooks published to mark the 50th and 60th anniversaries (1999 and 2009) of the People's Republic of China (PRC). Counties are the fourth level of administration in China (after State, Provincial and Prefectural level administrations) and the finest at which I could obtain economic data.[25] Although most provinces produced Anniversary Yearbooks, only a subset of them provided historical statistics at the county-level before and after the reforms. In all, I have comparable output data for the non-metropolitan areas of Gansu, Guizhou, Hebei, Jiangxi, Xinjiang and Zhejiang, and for some prefectures Sichuan and Shanxi (561 counties). For some variables, such as population I also have data for Jiangsu. The data coverage is highlighted in figure 1.3. The geographic coverage is reasonably representative of much of China but it does not cover the North-East, a region that has experienced a relative decline, or the booming South Coast. The counties in the data are also more rural than China as a whole as the data explicitly excludes most provincial capitals, which tend to be the largest cities. The dataset include about a quarter of Chinese counties and in 1978 and cover a population of 217 million people. If these counties were an independent country, then in 1978 they would have been the fourth most populous in the world.[26]

In principle the data cover the whole PRC era beginning in 1949, however, in practice data coverage varies by both province and variable, and is increasingly sparse in the early years of the PRC. To ensure the data is reasonably balanced I use data only from years where data is widely available: 1965, 1970, 1978, 1985, 1990, 1995, and 2000-08.[27] The

[25] Throughout the chapter the term 'counties' refers to all county-level administrative divisions. This also encompasses county level cities (which generally include urban and rural areas), districts, autonomous counties, banners and autonomous banners.

[26] After, the rest of China, India and the USA

[27] Where possible, data from yearbooks published in 1999 was supplemented with data from the University of Michigan's 'China Data Online' database to bring the data to 2008.

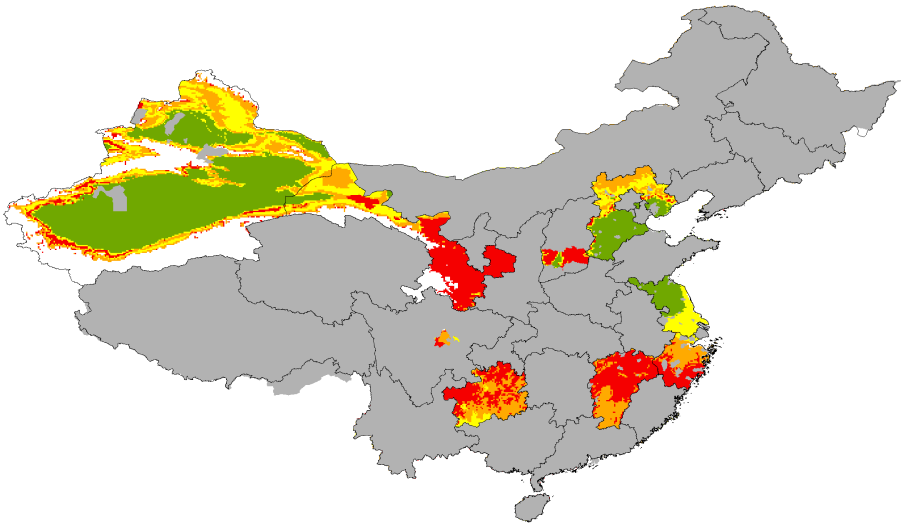


Figure 1.3: Data Coverage

inclusion of three 'pre-reform' years, 1965, 1970 and 1978, allows me to demonstrate that, prior to the reforms, the key parallel trends assumption was satisfied. The aggregate data used are Primary GDP and Gross Agricultural Output, as measures of agricultural output; non-Primary GDP, as a measure of non-Agricultural Output; rural income per capita; Savings Deposits, as a proxy for saving; Investment in Fixed Assets;[28] and Population. I also use physical production (in tonnes) of grain, cotton and oilseeds where the data is available to show that the pattern of production also changed in line with suitability for cash crops.[29] I match this economic data to the administrative boundary data described above.[30] To the best of my knowledge, this is the first study to exploit

[28]It is worth noting that Investment in Fixed Assets combines purchases of new and used capital and so does not capture 'investment' as it is normally understood by economists.

[29]For cotton, this is parts of Hebei, Xinjiang, Jiangsu. For oilseeds parts of Hebei, Xinjiang, Jiangsu, Zhejiang and one prefecture in Shanxi.

[30]In some cases, changes in county borders between 1999, the year of my boundary data, and 2009, the year of some of my yearbook data, necessitate the merging of counties to ensure a consistent match between borders and economic data.

the county level data contained in the Anniversary Yearbooks, however, Wang (2012) uses prefecture level data from the same sources in her study of the effect of China's Special Economic Zones.

Panel A of table 1.2 provides summary statistics for the main economic aggregates used for 1978, 85, 90 and 95. There are two features of the data that are worth highlighting. First, the economic aggregates grew extremely rapidly in the period studied. Between 1978 and 1990, real Primary GDP (my main measure of agricultural output) increased by almost 70%; real Secondary and Tertiary GDP (my main measure of non-agricultural output) almost quadrupled; real savings deposits increased more than tenfold; and real investment in fixed assets increased sixfold.[31] Second, as my data largely excludes metropolitan counties, and does not include any of the provincial level cities, my counties are more rural than China as a whole. In 1978, the Primary sector accounted for 56% of my counties GDP, compared to 28% for China as a whole. In 1978 the counties in my sample were similarly industrialised to the least developed countries in sub-Saharan Africa.

To get a sense of how unusual (or not) counties suitable for cash crops are, I provide estimated coefficients from linear regressions of a number of pre-reform (1978) outcomes and geographic variables on suitability in table 1.3. For most economic variables the relationship between suitability and income per capital is weak. However, counties suited to cash crops do have slightly higher population densities and aggregate output of secondary industry. They also have somewhat higher literacy rates but lower college enrollment. Not surprisingly given given the inputs to the GAEZ data, suitability is more strongly correlated with a number of climatic and geographic characteristics. In particular, places suited to cash crops are drier and flatter than those suited to grain. They also have

[31] There is some debate over the reliability of the deflators used by China's National Bureau of Statisitics (see Young (2003) for a discussion) so these figures should be considered indicative rather than definitive. In the empirical analysis I use log nominal variable and province-time fixed effects which means that I am automatically controlling for differential price changes across provinces. Consequently, the lack of reliable deflators is not crucial for my purposes.

Table 1.2: Selected Summary Statistics

A: Anniversary Yearbook Data

	1978	1985	1990	1995
Population (1,000's)	350.0	374.8	407.2	426.2
	(262.4)	(276.3)	(300.1)	(311.3)
Primary Share of	0.56	0.52	0.48	0.42
Nominal GDP[4]	(0.15)	(0.16)	(0.16)	(0.17)
Primary GDP[2]	3601	5073	6045	7799
(1978 Prices)	(2810)	(3883)	(4517)	(6297)
Secondary & Tertiary GDP[3]	3570	8504	14340	32131
(1978 Prices)	(6406)	(13607)	(21408)	(54504)
Savings Deposits	995	4646	11668	23452
(1978 Prices)	(1303)	(4934)	(12408)	(25863)
Investment in Fixed Assets	639	2512	3517	10584
(1978 Prices)	(1062)	(4678)	(6209)	(19597)
$Share_{it}$ of Cotton[1]	0.01	0.03	0.03	0.04
	(0.01)	(0.04)	(0.04)	(0.07)
$Share_{it}$ of Oilseed[1]	0.02	0.04	0.04	0.05
	(0.02)	(0.05)	(0.04)	(0.06)

B: Data from 1995 Industrial Census[5]

	State-owned	Non-state
Number of Firms	69,782	336,331
Gross Industrial	30252	7331
Output (1,000Y)	(297049)	(65158)
Net Value of Fixed	25184	2744
Assets	(260782)	(61616)
Labour Compensation[6]	3988	561
	(33185)	(3552)

Not all variables are observed for all counties and years. In particular, coverage for cotton and oilseed shares is substantially less complete than for other variables. Standard deviations in parentheses. Primary, Secondary and Tertiary GDP deflated by their respective national deflators. Savings and Investment deflated by the RPI.

(1) $Share_{ivt,c} = \frac{T_{it,c}}{T_{it,c}+T_{it,G}}$ where T is tonnage production of cash crop, c, or grain, G. (2) This is my main measure of agricultural output. (3) This is my measure of non-agricultural output. (4) This is the simple average of primary shares. The next two rows indicate the weighted average is somewhat lower. Not surprisingly, counties with larger economies tend to be less rural. (5) These data are calculated form the 1995 Census of Industries which covers all firms with independent accounting systems. I exclude firms from Tibet, Macao and Hong Kong. I also exclude firms from cities whose metropolitan areas cover more than one district (about 200 counties in total). (6) Wages + Welfare Expenses + Labour and Unemployment Insurance

Table 1.3: Correlations between Suitability for Cash Crops and other Variables of Interest

	β	S.E.
Population		
Ln Population	0.003	(0.050)
Ln Population Density	0.194	(0.149)
Measures of Income Per Capita		
Ln Net Rural Income Per Capita	-0.0401	(0.0397)
Ln GDP Per Capita	0.0330	(0.0337)
Aggregate Output		
Ln Primary GDP	0.0197	(0.0523)
Ln Secondary GDP	0.141*	(0.0789)
Ln Tertiary GDP	0.0500	(0.0508)
Ln Non-Agricultural Output	0.0897	(0.0614)
Ln Gross Agricultural Output	0.0037	(0.0698)
Primary Share of GDP	-0.0189	(0.0210)
Education (in 1982)		
Ln Literacy Rate	0.073***	(0.0234)
Ln College Enrollment	-0.079*	(0.0399)
Climatic and Geographic Factors		
Annual Rainfall (mm)	-231.0***	(42.28)
Average Temperature °C	0.008	(0.404)
Share of 'Flat' Land	0.300***	(0.0190)
Share of 'Intermediate' Land	-0.0230	(0.0213)
Share of 'Hilly' Land	-0.270***	(0.0158)
Absolute Suitability		
Ln Value of Grain Yield	0.112**	(0.0454)
Ln Value of Cash Crop Yield	0.432***	(0.0514)
Proximity to Cities and Infrastructure		
Ln Distance to International Airport (2008)	-0.221**	(0.0902)
Ln Distance to Commercial Airport (2008)	-0.046	(0.0736)
Ln Distance to Ports (2008)	-0.159	(0.108)
Ln Distance to 'Historic Cities'	0.235**	(0.109)

Coefficients from linear regressions of the form $Var_i = \alpha + \beta SCC_i^N + \varepsilon_i$. Data covers counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan. These are the provinces used for my main results. Unless otherwise stated, for variables which change over time the data is from 1978. Standard errors are clustered at the prefecture levels. (*** p<0.01, ** p<0.05, * p<0.1).

higher yields in both grain and cash crops, suggesting that they are more fertile.[32] Lastly, counties suited to cash crops are on average further away from international airports and ports (in existence in 2007), but closer to historic cities. It is thus not clear whether counties suited to cash crops are more or less connected to larger markets. To summarise, counties more or less suited to cash crops are broadly similar in terms of their economic characteristics but there are (not surprisingly) some differences in terms of their geographic characteristics. In the appendix, I show that these differences are not the underlying driver of the empirical results and that controlling for these factors effects neither their quantitative nor statistical significance.

1.4.3 Additional data sources

I supplement the data described above with additional data from several other sources including various province level economic data, county level data from China's 1982, 1990 and 2000 Population Censuses, and micro data from China's 1995 Third Industrial Census and 1990 Population Census. These and other additional sources of data are briefly described when needed in the results sections, and furhter details are provided in appendix A.2.

1.5 Agricultural Output

China's agricultural reforms improved effort incentives and liberalised the planting of cash crops. Improved incentives benefited farmers across China, but the freedom to plant cash crops was probably more beneficial to farmers with land suitable for those crops. In this section, I show that this was indeed the case.

[32]Consistent with the subsistence nature of pre-reform agriculture, log grain yields and log population density have the same relationship to suitability for cash crops. Unreported results cannot reject the null that the elasticity of population with respect to grain yields is 1.

1.5.1 Suitability for cash crops and agricultural output

Table 1.4 reports results of regressions showing that counties suited to cash crops had larger post-reform increases in agricultural output. A one standard deviation increase in my measure of suitability for cash crops is associated with 23% higher Primary GDP (my main proxy for agricultural output) between 1985-2008 (column 1). This increase is statistically significant at the 1 percent level. In column 2, my baseline specification, I show that around two-thirds of the increase in output was realised by 1985. Farmers were quick to take advantage of the reforms. To put these effect sizes into context, for the counties in my sample, real Primary GDP increased by 116% between 1978-95.

The province-time fixed effects allow for differential price changes across province but not within province. This could be problematic if the price of agricultural output increased faster in counties suited to cash crops. Fortunately, in the 1980's, most agricultural output was sold at fixed government prices and there were only modest changes in the relative price of different crops, the direction of which would have been disadvantageous to counties suited to cash crops until at least 1985(table 1.1). Thus, the short run effect on nominal output ought to provide a lower bound for the differential changes in real output. For later periods, trends in relative prices are less clear. The price of cotton and oilseeds increased compared to wheat, but fell compared to rice and maize.[33] Terms of trade improvements may explain some of the additional increase in output after 1985.

For many counties I do not observe Primary GDP in every year; my data is unbalanced. To rule out the possibility that changes in the composition of the sample drive the results, I reestimate my baseline specification using only counties for which I observe Primary GDP in every year (column 3). The estimated coefficients are almost unchanged and remain significant at the 1 percent level.

[33]The price of cotton and oilseeds fell dramatically compared to soybeans (following Chinese conventions a grain in my analysis) however soybeans is only the 'best grain' in my calculation of suitability in a few places due to it's low initial price.

Table 1.4: Agricultural Output

	Ln Primary GDP						*Ln Gross Ag. Y*		*Ln Rur. Ypc*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Suitability for Cash Crops × Post 78	0.230*** (0.066)								
Suitability for Cash Crops × 1985		0.162*** (0.057)	0.181*** (0.068)	0.142** (0.063)	0.172*** (0.052)	0.131** (0.059)	0.128* (0.074)	0.169*** (0.052)	0.165*** (0.050)
Suitability for Cash Crops × Post 85		0.236*** (0.068)	0.249*** (0.077)	0.203** (0.085)	0.245*** (0.059)	0.261*** (0.071)	0.215* (0.128)	0.236*** (0.090)	0.215*** (0.057)
Observations	8000	8000	6105	8000	7583	4199	4199	4778	7335
Counties	561	561	407	561	561	382	382	446	534
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Trends				Yes					
Data Restrictions			Balanced		No 1965	As (8)	As (7)		

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985, years after 1985, or years after 1978. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

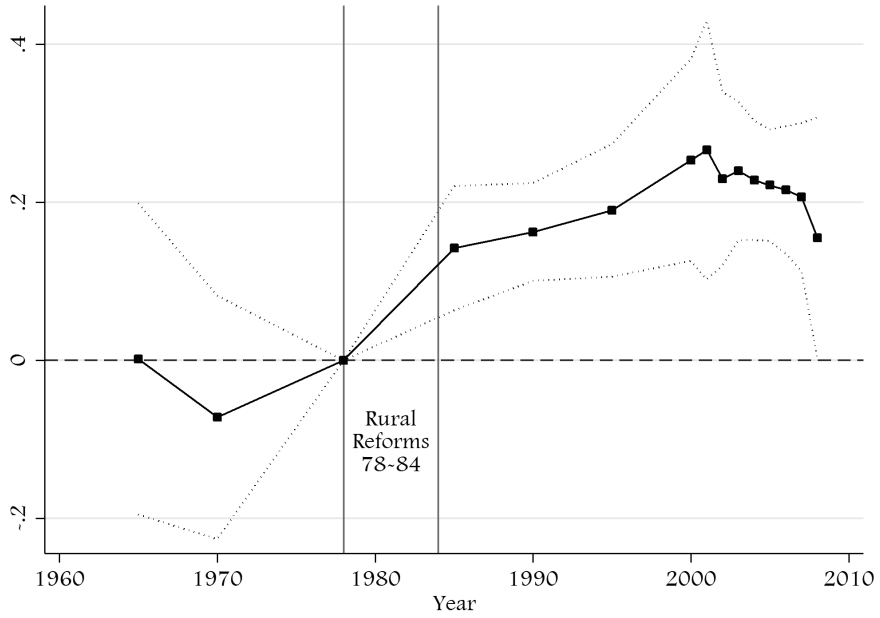


Figure 1.4: Coefficients of 'year' × 'Suitability for Cash Crops' (dependent variable: Ln Primary GDP)

By estimating separate coefficients for each year in the data, we can observe the differential growth in agricultural output in counties relatively suited to cash crops over time. Figure 1.4 plots these coefficients and the associated 95% confidence intervals (estimating Equation 1.11). The estimated coefficients on the pre-reform years indicate that pre-reform growth in agricultural output was uncorrelated with suitability. Counties more or less suited to cash crops were following parallel trends. Immediately after the reforms, counties suited to cash crops enjoyed a large relative increase in agricultural output. These increases are sustained until 2008, the last year in my data. We cannot reject that all coefficients from 1990 onwards are equal, suggesting that specialisation in cash crops led to a one time increase in agricultural output.

As an additional test of the parallel trends assumption, I include county specific time trends for all 561 counties (table 1.4, column 4). These time trends flexibly control for any (log) linear differences in agricultural output growth across counties. My estimated coefficients are almost

identical to those in my baseline specification and are significant at the 5 percent level. Again the results do not appear to be driven by parallel trends.

Even though counties followed parallel trends in agricultural output before the reforms, it remains possible that suitability for cash crops was spatially correlated with other post-reform shocks. I address this concern by providing a large number of robustness checks and alternative specifications in the appendices. First, I show that the estimated coefficients are stable in the face of several alternative fixed effects specifications. This stability indicates that the hypothetical confounders are correlated with suitability for cash crops after the reforms in the same way within prefectures, provinces and across the whole of China. This seems unlikely. Second, I control for the effect of a large number of pre-reform characteristics which may have become more valuable in the reform era. These include, GDP per-capita, agricultural share of GDP, population density, education, distance to major cities and airports, ruggedness of terrain and absolute productivity in cash or grain crops. The results are quantitatively and qualitatively unchanged. I also show that my results are robust to alternative ways of calculating suitability for cash crops, and that they do not rely on variation provided by any one province.

Chinese rural institutions were (somewhat) liberalised between the end of the Great Leap Forward (1963) and the start of the Cultural Revolution (1966). The first year in my data, 1965, is in this period. As a precaution, I reestimate my results without including 1965 (column 5). The results are almost identical to my baseline results.

I have assumed a linear relationship between suitability for cash crops and post-reform agricultural output growth. If the relationship were non-linear, my regressions would be mis-specified. In figure 1.5 panel A, I provide smoothed local polynomial plot, with 95% confidence bands, of the residuals from regressions of suitability for cash crops and growth in agricultural output on province fixed effects. I.e. the variation in suitability and growth not explained by province specific factors. The

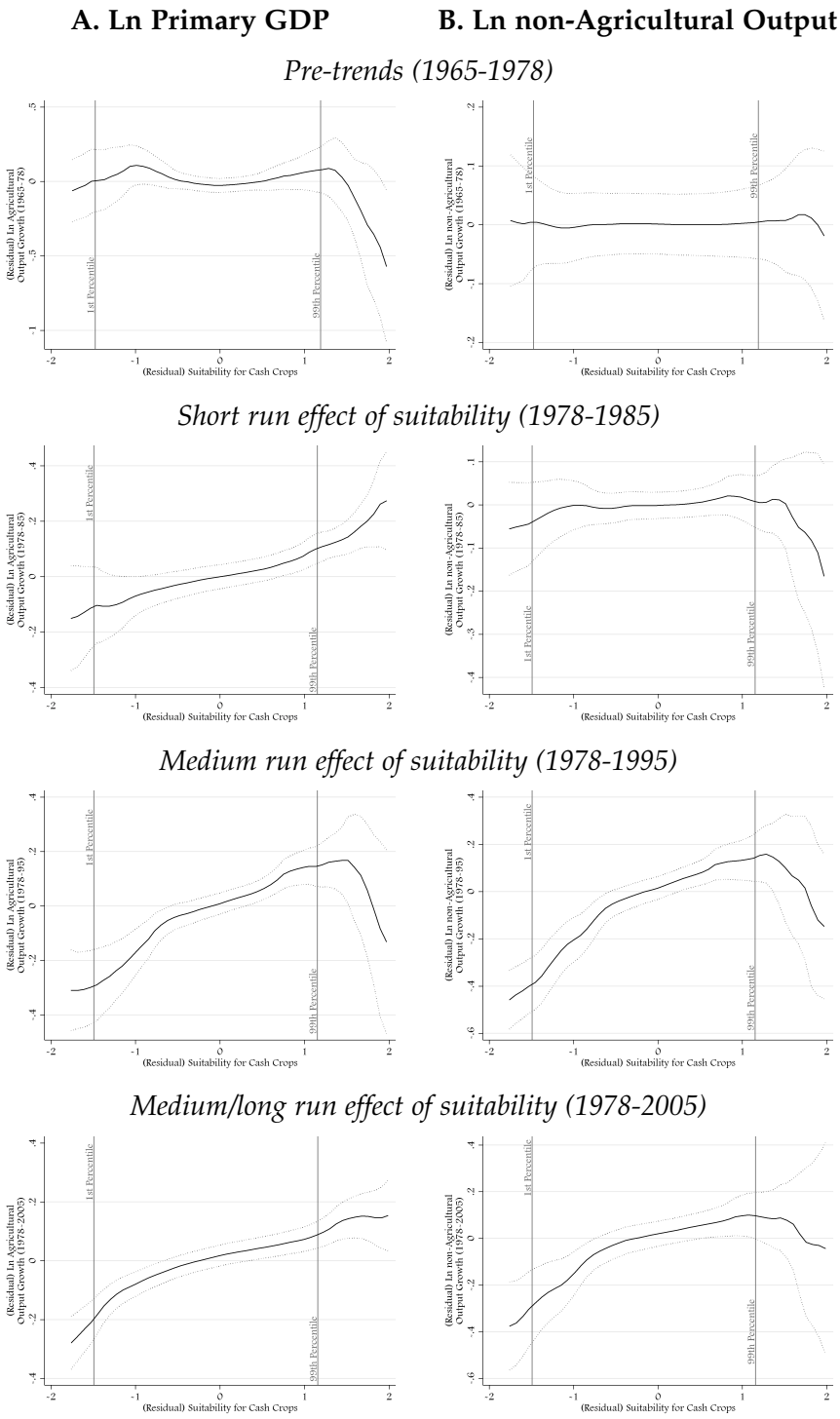


Figure 1.5: Smoothed Polynomial relationship between Suitability for Cash Crops and Growth of Outcome of Interest (residuals after controlling for province level changes)

relationship between agricultural output growth and suitability for cash crops was approximately linear for the periods 1965-78, 1978-85, -95 and -2005. The flat relationship between growth and suitability between 1965-78 provides an additional visual representation of parallel trends prior to the reform. The positive slope for the periods after the reforms indicates the benefits of specialisation in cash crops.

The results thus far use Log Primary GDP as a proxy for agricultural output. In addition to agricultural value added, Primary GDP also includes the potentially confounding value added of other sectors such as mineral and gas extraction. For a smaller number of counties I have data on Gross Agricultural Output, so to validate the use of Primary GDP, I reestimate my baseline specification with Log Gross Agricultural Output as the dependent variable (columns 7 and 8). The results are similar to my baseline results. Primary GDP appears to be a good proxy for agricultural output. In column 9, I estimate the effect of suitability for cash crops on Log Rural Income per Capita. Rural incomes increased similarly to Gross Agricultural Output and Primary GDP.

Aggregate gains in agricultural output

If we are willing to assume that these estimates are real increases in agricultural output due to specialisation in cash crops, rather than reallocations of output across space, then the estimated coefficients can be used to construct a back of the envelope estimates of the total increase in agricultural output due to specialisation. This type of estimate can provide a sense check of the plausibility of the estimated coefficients and allows comparison to the gains from specialisation attributed to decommunalisation by McMillan et al. (1989) and Lin (1992).

I focus on increases in agricultural output between 1978 and 1985 for three reasons. First, the potentially confounding effect of relative price changes is minimised over this period; there is only a small across the board decline in the relative price of cash crops. Second, in the next section, I will show that by 1985 there is little effect on non-

agricultural output, whereas after this non-agricultural output increased substantially in counties suited to cash crops. Higher non-agricultural output could potentially increase or decrease agricultural output, but I wish to focus primarily on the gains from specialisation. Third, focusing on 1978-85 facilitates comparison to previous estimates of the gains from decommunalisation which were usually estimated over the period 1978-84.

To estimate the aggregate gains, I reestimate my baseline specification using only data from 1978 and 1985. The estimated coefficient is 0.14, slightly smaller than the coefficient of 0.16 obtained for 1985 in my baseline specification. As my coefficient is a diff-in-diff coefficient, we cannot be sure whether the coefficient captures increases in output all the way through the distribution. However, as relative prices did not change, there is no particular reason why counties unsuited to cash crops would be actively harmed by the freedom to plant cash crops. Nevertheless, I will make the conservative assumption that although no counties were actively harmed, the counties least suited to cash crops gained no benefit. County i's assumed increase in agricultural output due to specialisation is $d_i = \beta \times \max\{SCC_i^N - P_x(SCC^N), 0\}$, where SCC_i^N is the normalised suitability for cash crops, $P_x(SCC^N)$ is the suitability for cash crops of the county at the percentile x below which there are assumed to be no gains and β is effect of comparative advantage on the growth of agricultural output. I consider three 'zero gains percentiles' for x: 10, 25 and 40.[34]

I use this estimate of the increase in gains in two ways. First, to estimate the total increase in agricultural output due to specialisation in my data I combine estimates, $\hat{d}_i$, with the fitted values of my regression. Table 1.5, panels A and B contain the estimates. When the gains are estimated based on coefficients on regressions of Ln Agricultural Output on suitability, I estimate that, for the counties in my data, specialisation increased aggregate agricultural output by between 9.0 and 15.3 percent.

[34]For consistency with the extrapolated gains for the whole of China, I I use the percentiles of all Chinese counties, not just the ones used to estimate b. However, these percentiles are extremely similar and so their use do not substantively change the estimates.

Table 1.5: Aggregate Increases in Agricultural Output due to Specialisation in Cash Crops (1978-1985)

No gains below percentile...	10	25	40
A. Gains calculated from fitted values (log specification)			
% Increase	15.3	11.0	9.0
B. Gains calculated from fitted values (levels specification)			
% Increase	14.0	10.1	8.3
Share of Total Increase	0.22	0.16	0.14
C. Gains imputed from 1982 agricultural employment and suitability for cash crops (log specification)			
All China (%)	18.3	14.2	11.8
Sample Provinces (%)	15.6	11.5	9.6
Sample Provinces, no Cities (*Shi*) (%)	15.8	11.7	9.8

The 'no gains below percentile' is the percentile of county level suitability for cash crops below which it is assumed that counties did not benefit at all from agricultural specialisation. I assume that above this percentile the gains from specialisation increase linearly in suitability for cash crops (log linearly Panels A & C). In panel C I take the weighted average expected increase in agricultural output due to specialisation in cash crops.

My preferred estimate, based on no gains below the 25th percentile of suitability, indicates that specialisation increased output by 11 percent. When I do the same exercise using agricultural output in levels, I obtain a similar estimated increase of 10.1 percent. The advantage of levels estimation is that I can estimate the share of the total increase in agricultural output without the use of unreliable Chinese agricultural price deflators. In my data 16% of the increase in agricultural output between 1978 and 1985 was due to specialisation.[35]

In panel C, I extrapolate these gains across the whole of China using the comparative advantage of all counties. Each county is assumed to have had a d_i log point increase in agricultural output due to specialisation. I then take a weighted average of the counties increase

[35]The increase in agricultural output due to specialisation when using log estimates is $\frac{\sum_i \exp(\hat{d}_i)}{\sum_i \exp(\hat{y}_{1985}-\hat{d}_i)}$, when in levels $\frac{\sum_i \check{d}_i}{\sum_i \check{y}_{1985}-\check{d}_i}$, the share of the increase when in levels is $\frac{\sum_i \check{d}_i}{\sum_i \check{y}_{1985}-\check{y}_{1978}}$

where the weights are based on the imputed share of national agricultural output in 1978.[36] Specialisation is estimated to have increased agricultural output by 14.2 percent across the whole of China, three percentage points more than that estimated for counties in my main data set using the fitted values. If I 'extrapolate' my results only to counties in the provinces and prefectures in my main data set, the estimated gains are similar to those indicated by the fitted values. The rest of China appears to have been slightly better placed to gain from specialisation than the counties in my data.

The large gains I find are consistent with Lardy (1983), who argued that the pre-reform misallocation of crops to land imposed a substantial cost in terms of agricultural productivity. Specialisation increased agricultural output by around two-thirds the amount usually attributed to the introduction of the Household Responsibility System. (Although we would expect the two parts of the reform to be complementary.) Gains from specialisation help bridge a gap between the large gains in aggregate output attributed to the reforms by McMillan et al. (1989) and Lin (1992), and the smaller effect on rice yields in Huang and Rozelle (1996). They are also consistent with the large gains from economic integration of US agriculture estimated by Costinot and Donaldson (2014) who find that integration of agricultural markets increased the value agricultural output by 1.5 percent *per annum* for most of the last 130 years.

The importance of fine spatial variation

Gains from reallocation appear to have been of economic significance, yet previous empirical studies have not been able to identify them (Lin, 1992; Lin and James, 1995). My empirical methodology differs from that used in previous studies in two principal ways. Firstly, the measures of potential or realised gains are different. Where they use changes in the shares of cash crops planted, or historical patterns of crop production, I

[36] The weight w_{ij} placed on county i in province j is
$w_{ij} = ProvinceShareOfNationalPrimaryGDP_j \times CountyShareofProvincialAgriculturalPopulation_{ij}$.

use the GAEZ global database of theoretical agricultural productivities to identify land suitable for growing cash crops. Secondly, where they used province level data, I use county level data. I am therefore able to exploit much finer spatial variation in suitability than previous studies and to include a richer set of fixed effects. While I lack the data to replicate their methodologies at the county level, I am able to replicate my own methodology with province level data.

Table 1.6 contains results based on province level data and comparable results from my county level data.[37] My baseline specification includes province-by-time fixed effects which are collinear with my variable of interest using province-level data. To avoid this collinearity, I provide two additional specifications. The first uses only time fixed effects, the second adds province specific time trends. Columns 2 and 3 provide county level estimates of the effect of suitability on post-reform agricultural output for these specifications; the results are similar to my baseline findings (restated in column 1).

Columns 4-7 report results obtained using province level data. Columns 4 and 5 restrict the set of years to those used in the county level analysis. Columns 6 and 7 use data from all available years. Regardless of restrictions on years, or specification, the estimated coefficient on suitability for cash crops is neither economically nor statistically significant. These results highlight the importance of using data at the right level of spatial disaggregation.

1.5.2 Change in the pattern of agricultural production

For a subset of counties, my data includes physical production, in tons, of grain, cotton and oilseed.[38] For counties with this data, I can test whether counties suited to growing cotton (or oilseed) actually grew more cotton

[37] Because the province level data has observations available for each year, I provide results for specifications where post 1978 is the treatment period rather than estimating the effects for 1985 and 1990 onwards separately.

[38] I observe output of grain, cotton and oilseed for most counties in Hebei, Jiangxi and Xinjiang. I also observe output of grain and oilseed for most counties in Zhejiang and Chengdu prefecture in Sichuan.

Table 1.6: Agricultural Output: Level of Aggregation

	Ln Primary GDP (County)			*Ln Primary GDP (Province)*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Suitability for Cash Crops × Post 1978	0.230*** (0.066)	0.225*** (0.032)	0.150*** (0.042)	-0.000 (0.064)	0.047 (0.052)	0.022 (0.053)	0.031 (0.035)
Observations	8000	8000	8000	463	463	1862	1862
Counties	561	561	561				
Provinces				31	31	31	31
County FE	Yes	Yes	Yes				
Province FE				Yes	Yes	Yes	Yes
Time FE		Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes						
Province Trends			Yes		Yes		Yes
Years				Restricted	Restricted	1949-2011	1949-2011

Columns 1-3 robust standard errors two-way clustered at the prefecture and province-by-time levels; columns 4-7 robust standard errors clustered at the provincial level (*** p<0.01, ** p<0.05, * p<0.1). Columns 1-3 estimated using county level data. Columns 4-7 estimated using more aggregated province level data. Suitability for cash crops is the (standardised, county or province average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction term is a dummy years after 1978. Columns 1-5 use data for 1965, 1970, 1978, 1985, 1990, 1995 & 2000-2008 (the years which county level data is widely available). County level data is from non-metropolitan counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan. Province level data is for the whole of China excluding Macao and Hong Kong.

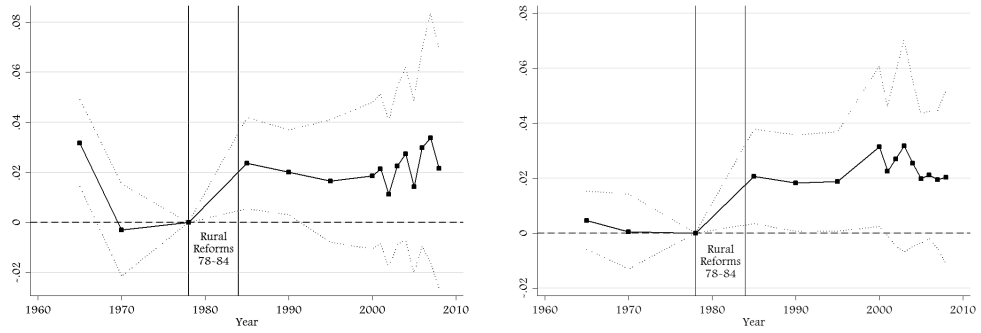
(or oilseed) after the reforms. To do this, I calculate the share of cotton (oilseed) tonnage in joint tonnage of cotton (oilseed) and grain

$$Share_{ivt,c} = \frac{T_{ivt,c}}{T_{ivt,c} + T_{ivt,G}}$$

where $T_{ivt,c}$ is the tonnage of crop c at time t in county i and province v. Analogously to the construction of my measure of suitability for cash crops, I also construct variables for suitability to cotton and oilseeds with respect to grain as described in section 1.4. If the pattern of production is shifting towards the one suggested by crop suitability, counties more suited to cotton (oilseed) ought to increase the share of cotton (oilseed) in their output.

It is important to note that the set of counties for which I have data on the physical production of cash crops include only counties that produce that crop. The data appear to exclude counties that never produced cash crops, and is thus not a random sample. As a consequence, I am identifying increased specialisation only from counties relatively suited to cash crops. Indeed, counties for which I have data on the production of cotton and oilseeds had suitabilities for cash crops 0.8 and 0.4 standard deviations higher than the average Chinese county. As the production and planting of cash crops increased rapidly after the reform, the result of this is likely to bias the estimated coefficients towards zero, as the places with zero growth in cash crop production seem to be excluded from the data and have low suitability for cash crops.

Figure 1.6 plots the the coefficients associated with the effect of suitability for cotton and oilseeds on the share of their respective physical outputs for each year in the data. For both cotton and oilseeds, the physical share of output increases after the reforms (although the increase is not statistically significant at the 5 percent level in many years). For oilseeds there is no differential trend in shares prior to reform. For cotton, areas more suited to its production had a significantly higher share of cotton in 1965 than in 1970 or 1978. This may be due to the slight liberalisation of agriculture between the Great Leap Forward and



A. dep. var: Cotton Share B. dep. var: Oilseeds Share

Figure 1.6: Coefficients of 'year' × 'Suitability for Cotton (Oilseeds)'

the Cultural Revolution (although this is not evident in the main results for agricultural output).

Table 1.7 contains similar results. Columns 1-3 provide the results for cotton; a 1 standard deviation increase in suitability for cotton is associated with around a 1-2 percentage point increase in the share of cotton in output. The coefficients are not always statistically significant.[39] Columns 4-6 provide the results for oilseeds; a 1 standard deviation increase in the relative value of oilseed production is associated with a 2 percentage point increase in the share of cotton in joint cotton and grain tonnage. Columns 2 and 5 also include suitability to the 'other' cash crop in my data (i.e. for cotton this means oilseeds). The estimated coefficients are weakly negative, which is consistent with specialisation in cotton crowding out oilseeds, and vice versa. Columns 3 and 6 omit data from 1965 in case the post great leap forward liberalisation is affecting the results. As figure 1.6 would suggest, the estimated effect on the share of cotton increases.

[39]Because of the limited availability of physical production data, errors are clustered at the county level instead of the prefecture and province-time level to ensure that the errors are consistently estimated. If two-way clustering is included at the prefecture and province-year level as in my main regressions, the standard errors associated suitability for cotton interacted with 1985 are much smaller for columns 1-3, while the standard errors associated with the post interactions are significantly larger. Results available on request.

Table 1.7: The Pattern of Production

	Share of Cotton			*Share of Oilseeds*		
	(1)	(2)	(3)	(4)	(5)	(6)
Suitability for Cotton	0.013*	0.015*	0.026***		-0.005*	
× 1985	(0.007)	(0.008)	(0.009)		(0.003)	
Suitability for Cotton	0.011	0.014	0.024*		-0.001	
× Post85	(0.014)	(0.014)	(0.013)		(0.004)	
Suitability for		-0.004		0.019**	0.017**	0.020**
Oilseeds × 1985		(0.010)		(0.008)	(0.008)	(0.008)
Suitability for		-0.032		0.021*	0.021*	0.023*
Oilseeds × Post		(0.020)		(0.011)	(0.012)	(0.012)
Observations	3505	3505	3277	5266	5266	4919
Counties	281	281	280	366	366	366
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Data			No 65			No 65

Robust standard errors clustered at county level (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cotton (oilseed) is the (standardised, county average) ratio of the value of output of cotton (oilseed) to the value of output of the best grain crop. Interaction terms are dummies for 1985, years after 1985. Share of cotton or oilseed is $Share_{ivt,c} = T_{it,c}(T_{it,c} + T_{it,G})^{-1}$ where T is tonnage production of cash crop, c, or grain, G. Data from cotton or oilseed producing counties in Hebei, Jiangxi, Xinjiang, and oilseed producing counties in Zhejiang and part of Sichuan, for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

Both oilseeds, and especially cotton, have a lower yield (by weight) than grain. The average GAEZ predicted cotton yield in tons in Jiangxi, Hebei and Xinjiang—the provinces for which data on cotton production is available—is 1/12 that of the average predicted grain yield, while the average reported realised yield of cotton (in 1978) is 1/8 that of grain.[40] The respective figures for oilseeds are 1/2 and 1/3. A 2 percentage point increase in the share of output in tons is likely to equate to a significantly larger percentage point change in land use.

With some assumptions, it is possible to produce a back of the envelope estimate of the gains from switching to cotton (or oilseeds). If a county has one unit of land $L = L_C + L_G = 1$, which is the sole input into agricultural production, and is endowed with Hicks Neutral productivities A_C and A_G in cash crops and grain respectively, then agricultural output is $Y = A_G L_G + A_C L_C$ and so growth in agricultural output is

$$\frac{Y_{Post}}{Y_{Pre}} = \frac{A_G L_{G,Post} + A_C L_{C,Post}}{A_G L_{G,Pre} + A_C L_{C,Pre}} = \frac{L_{G,Post} + \frac{A_C}{A_G}(1 - L_{G,Post})}{L_{G,Pre} + \frac{A_C}{A_G}(1 - L_{C,Pre})} \tag{1.13}$$

Let us consider the growth in agricultural output in a county with suitability for cotton one standard deviation above the mean as opposed to one with mean suitability $\frac{A_C}{A_G} = 1.68$ compared to $\frac{A_C}{A_G} = 1.01$. Within the counties for which data is available, the share of cotton in output is almost uncorrelated with suitability for cotton prior to the reforms. (Recall, that the counties for which share of cotton is available for are a selected sample of counties which actually produce cotton.) Consequently, I assume that prior to the reforms, cotton constitutes 1% tonnage output (the mean indicated in table 1.2), and thus around 10% of planted area given the relative weight of cotton and grain after the reforms. The results in table 1.7, indicate that a one standard deviation increase in suitability for cotton is associated with an additional 0.015 increase in tonnage output, or around 15% of land area. As the mean

[40] Data on realised yields from the University of Michigan's China Data Centre.

share of cotton output also increased, let us consider two scenarios. (a) the share of cotton in the mean county is unchanged after the reform. (b) the share of cotton in the mean county increases after the reform - for the sake of exposition, say by 0.005, or 5% of planted area.

In scenario (a) there is no increase in agricultural output due to switching in the mean county, whereas output in the county suited to cash crops increases by 9.4%. In scenario (b) in the mean county output increases by 0.5%, whereas output in the county suited to cash crops increases by 31.4% — a 30.8% increase compared to the mean county. The gains from switching increase in suitability both on the extensive and intensive margins. The aggregate gains in agricultural output observed do not appear to be inconsistent with the changes in the composition of output — despite ignoring the heterogeneity in suitability that undoubtedly exists within county and any effect on the provision of labour, capital, intermediate inputs and effort that growing cash crops may have induced.

An alternative explanation for the changes in crop shares, and output, is that yields grew faster for cash crops, without any reallocation of land to crops. If counties suited to cotton were producing and planting more cotton prior to reform, and cotton yields grew faster than wheat yields after the reforms, then these counties would have faster growth in agricultural output and increase the share of cotton in their output. Yields in China are endogenous to the reforms, if the average suitability of land used to grow cash crops increased faster than that for grain then the reforms themselves would cause a relative change in yields. However, yields outside of China are more plausibly exogenous. Table 1.1 shows that differences between post-reform yield growth in cash crops and grains in the US and India was modest and far too small to explain the differential growth observed.[41]

[41] In 1978, for the counties where I have data, cotton and oilseeds were were 1% and 1.7% of grain output respectively and even at the ninetieth percentile of output share, cotton was only 2.2% of grain tonnage and oilseeds only 3.7%.

1.6 Linkages to the Non-Agricultural Sector

After the reforms, counties suited to growing cash crops began specialising and, as a consequence, enjoyed faster growth in agricultural output. In this section I will show that these counties also had more rapid growth in non-agricultural output. I will show that the increases in non-agricultural output were accompanied by higher savings and investment. As discussed in section 1.2, these aggregate increases are consistent linkages through several channels. Thus, I will provide several pieces of supplementary evidence which suggest that the increases in non-agricultural output identified were primarily due to the *capital channel*. Conversely, these additional results do not indicate that specialisation in cash crops was labour saving, or that there were substantial county-level linkages via local demand. These findings are consistent with the significant geographic capital market frictions described in section 1.3.

1.6.1 Non-agricultural output

Figure 1.7 and table 1.8 contain my main reduced-form results for non-agricultural output: counties suited to growing cash crops had significantly faster post-reform growth.

Figure 1.7 plots coefficients and 95% confidence intervals from a regression estimating the effect of suitability for cash crops in each year (1978 is the omitted year). A coefficient of 0.1 would indicate that a 1 standard deviation increase in suitability was associated with an approximately 10% increase in non-agricultural output. The coefficients on the pre-reform years provide a placebo test of the parallel trends assumption. All the coefficients on the pre-reform years are insignificant and close to zero with no discernible trend over time. After the reforms, counties suited to growing cash crops enjoyed significantly faster non-agricultural output growth.

The estimated cumulative differential increase in output peaked in the early 2000's and declined thereafter. The reason for this apparent decline

Table 1.8: Non-Agricultural Output: Reduced Form Results

	Ln Non-Agricultural GDP			*Sec. GDP*	*Ter. GDP*
	(1)	(2)	(3)	(4)	(5)
Suitability for Cash Crops × 1985	0.022	-0.016	0.022	0.023	0.009
	(0.031)	(0.023)	(0.046)	(0.064)	(0.035)
Suitability for Cash Crops × Post 85	0.181**	0.167**	0.195**	0.197*	0.168***
	(0.072)	(0.081)	(0.083)	(0.106)	(0.057)
Observations	7993	6060	7993	7999	7993
Counties	561	404	561	561	561
First Stage as First Stage F					
County FE	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes
County Trends			Yes		
Data		Balanced			

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

is beyond the scope of this chapter. However, it is worth noting that share of rural enterprises in industrial output peaked in the late 1990's, as large export oriented and foreign invested firms became increasingly important (Huang, 2008). I will later provide evidence that these increases in non-agricultural output were primarily due to higher agricultural surpluses increasing the supply of local capital. Given this, it is possible that local savings were particularly important for rural firms, which were key to China's industrial output growth in the 1980's and early 1990's, but less important to the urban firms which dominated subsequently. Alternatively, the decline may reflect a lessening of geographic capital market frictions, possibly due to the banking sector reforms instituted in the wake of the Asian financial crisis. This second hypothesis is

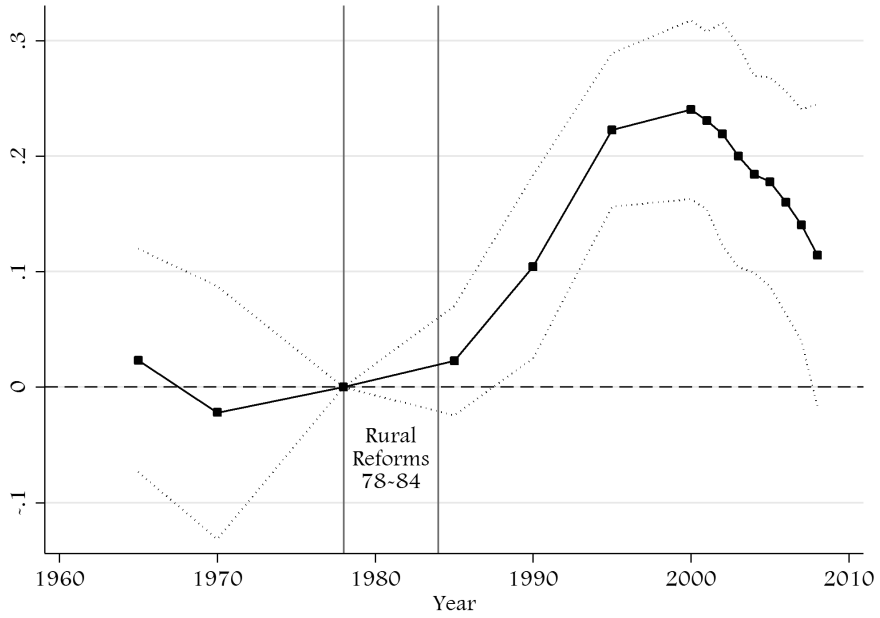


Figure 1.7: Coefficients of 'Year' × 'Suitability for Cash Crops' (dependent variable: Ln Non-agricultural Output)

also consistent with the apparent reduction in geographic capital market frictions shown in figure 1.1.

It is important to note that in 1985, the first post-reform year for which I have data, the differential growth in non-agricultural output is small (but positive) and statistically insignificant. There are several factors that make a failure to find an increase in 1985 unsurprising. First, the 'dual-track' reforms, which provided non-state firms with access to many intermediate goods markets, were not introduced until 1984. Second, I will later show that the increase in non-agricultural output was due to an increase in the supply of capital, if capital accumulation takes time, 1985 may be to soon to see its full effects. Third, if, as I will show, specialisation increased the demand for agricultural labour, the short run effect of reforms on the non-agricultural sector could be negative until sufficient capital accumulates to offset the higher wages faced. Fourth, although the non-state sector was growing very rapidly, in 1985 its output was still a small, and most likely poorly measured, share of total output.

Increases in non-state output may thus have been hard to detect as early as 1985.

Table 1.8 contains my main reduced form results for non-agricultural output. In my baseline specification, a one standard deviation increase in a counties comparative advantage is associated with 19% higher non-agricultural output between 1990-2008. This estimate is significant at the 5 percent level. As in figure 1.7, the estimated effect for 1985 (immediately after the reforms) is small and statistically insignificant. Although the later increase is large, it must be seen in the context of the, on average, nine-fold increase in real non-agricultural output enjoyed by my counties between 1978-95. When I restrict the sample to a balanced panel of counties I obtain very similar estimates (column 2); the results are not due to changes in the composition of the sample over time. Including county specific time trends also has no effect on the estimated coefficients and provides further support for the key parallel trends assumption (column 3).

While there were parallel trends in non-agricultural output before the reforms, it remains possible that suitability for cash crops was spatially correlated with other post-reform shocks. I address this concern by providing a large number of robustness checks and alternative specifications in the appendices. First, I show that the estimated coefficients are stable in the face of several alternative fixed effects specifications. This stability indicates that any unobserved confounders are correlated with suitability for cash crops in the same way within provinces as across the whole of China. Second, I control for the effect of a large number of pre-reform characteristics which may have become more valuable in the reform era. These include, GDP per-capita, agricultural share of GDP, population density, education, distance to major cities and airports, ruggedness of terrain and absolute productivity in cash or grain crops. The results are quantitatively and qualitatively unchanged. I also show that my results are robust to alternative ways of calculating suitability for cash crops, and that they do not rely on variation provided by any one province.

As with agricultural output, I have assumed a linear relationship between suitability for cash crops and growth. In figure 1.5 panel B I provide a smoothed local polynomial plot, with 95% confidence bands, of the residuals from regressions of suitability for cash crops and growth in non-agricultural output on province fixed effects. The relationship between non-agricultural output growth and suitability for cash crops was approximately linear for the periods 1965-78, 1978-85, -95 and -2005. The flat relationship between growth and suitability between 1965-78 provides an additional visual representation of parallel trends prior to the reform.

In columns 4 and 5, I reestimate my baseline specification with Secondary and Tertiary GDP as separate outcomes. I obtain similar results for both sectors, so for the sake of brevity, I proceed using combined 'non-agricultural output'. Depending on ones priors, obtaining similar coefficients in regressions of both Secondary and Tertiary GDP could be evidence for or against more than one mechanism. If the output of the secondary and tertiary sectors were differentially tradable then the *demand channel* would effect the less tradable sector more strongly. Alternatively, if secondary output was more capital intensive, then we would expect the *capital channel* to increase secondary output more. However, if state-owned firms were relatively dominant in the secondary sector then the *capital channel* would increase tertiary output more, as fewer tertiary firms would have access to the national banking system. The fact we obtain similar coefficients is thus not particularly informative of why non-agricultural output increased.

Instrumental variables results

The identification of linkages between the agricultural and non-agricultural sectors is ordinarily plagued by endogeneity issues, not least the scope for reverse causality. The reduced form results suggested a causal link between agricultural and non-agricultural output, and that suitability for cash crops is a potential instrument for agricultural output. For

Table 1.9: Non-Agricultural Output: Long Differenced IV Results

	$\Delta_{1978-1995}$			$\Delta_{1978-2005}$		
	(1) OLS	(2) 1st St.	(3) IV	(4) OLS	(5) 1st St.	(6) IV
Δ Ln Primary GDP	0.344***		1.168***	0.264***		0.804***
	(0.066)		(0.261)	(0.074)		(0.303)
Suitability for Cash Crops		0.222***			0.180***	
		(0.045)			(0.068)	
Counties	538	538	538	528	528	528
First-Stage F (AP)			22.75			36.37
Province FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors clustered at the prefecture level (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan.

this instrument to be a valid, it must only affect non-agricultural output through agricultural output. The primary concern in this regard, is that suitability for cash crops is correlated with some other characteristic that became increasingly important in the reform era. However, the large number of robustness checks provided for the reduced form results in appendix A.3 should allay these fears.

I implement the IV regressions using 'long difference' specifications of the form

$$Ln(y_{iT}^{NA}) - Ln(y_{i1978}^{NA}) = \delta_v + \beta(\widehat{Ln(y_{iT}^{A}) - Ln(y_{i1978}^{A})}) + \varepsilon_{iv} \qquad (1.14)$$

where Y_{iT}^{NA} is non-agricultural output in year T and δ_v is a province fixed effect. As this specification includes province fixed effects, I am once again exploiting only within province variation.

As with all instrumental variable specifications, we must be clear in stating exactly what it is we are identifying. In this case the 'local average treatment effect' is the elasticity of non-agricultural output (at the county level, over a given time period) with respect to increases in

agricultural output due to post-reform specialisation in cash crops. The extent to which this is likely to generalise to other contexts will depend on how similar the situations are. I provide some discussion of this in the conclusion.

I estimate the results over two time periods, 1978-1995 and 1978-2005. Given the pattern of coefficients in figure 1.7—in particular the apparent decline in the effect on non-agricultural output from the early 2000's—both sets of results are probably medium run elasticities. Table 1.9 columns 1 and 4 provide the (endogenous) OLS estimates. The estimated elasticities are 0.34 and 0.26, indicting a 1% increase in agricultural output is associated with around a 0.3% increase in non-agricultural output. Columns 2 and 5 contain the results of the first stage regressions—not surprisingly, suitability for cash crops is strongly correlated with the growth of primary GDP. Columns 3 and 6 contain the IV estimates indicating elasticities of 1.2 and 0.8 over 15 and 25 year periods. These estimates are significant at the 1 percent level. There are a number of reasons why we might expect the IV estimates to be larger than those obtained using OLS. First, IV will mitigate the effect of the (possibly substantial) measurement error in the independent variable, which generally introduces downward bias into OLS estimates. Second, increases in non-agricultural output could ordinarily crowd out agricultural output and introduce negative reverse causality. Third, increases in agricultural output could have been particularly valuable at the start of the reform era, perhaps due to the compounding effect of high returns on capital.

1.6.2 Savings and investment

Higher post-reform increases in agricultural output resulted in higher manufacturing and service sector output. I will later provide supplementary evidence that suggests that linkages identified are primarily due savings from agriculture being invested in the local non-agricultural sector. However, for this to be the case, it ought to be that higher

agricultural output did, in fact, result in higher savings and investment. In this section, I show that counties with land suitable for growing cash crops also had faster post-reform growth in both household savings and investment in fixed assets.

Table 1.10 column 1 provides the baseline results. A one standard deviation increase in suitability for cash crops is associated with 19% higher savings deposits (a stock) in 1985 and 23% higher savings deposits for the period 1990-2008. The results are significant at the 10 percent level. Households appear to have saved a significant portion of the surplus generated by specialisation in cash crops. For investment in fixed assets (a flow), there was no differential increase in investment in 1985, but from 1990-2008, a one standard deviation increase in suitability is associated with a 35% increase in investment. This estimate is significant at the 1 percent level. Data on investment in fixed assets and, in particular, savings deposits, is less widely available than data on agricultural and non-agricultural output which reduces the precision of the estimates.

Figures 1.8 and 1.9 plots the estimated coefficient on suitability for each year in my data. The coefficients for savings deposits mirror those for agricultural output, while those for investment in fixed assets look more like those for non-agricultural output. The increase in savings precedes the increase in investment and non-agricultural output, which is consistent with a larger agricultural surplus being used to finance non-agricultural investment, and the likely limited capacity of the non-state sector to absorb capital in the early reform era. For both savings deposits and investment in fixed assets, there is no evidence of differential trends prior to the reforms, lending further support to the parallel trends assumption.

For both savings and investment, in table 1.10 column 2, I drop observations from Jiangsu to improve comparability with my main results. In column 3, I restrict the sample to county-year observations where data for both savings deposits and investment in fixed assets are available, making the coefficients more comparable. Column 4 includes

Table 1.10: Savings and Investment

	(1)	(2)	(3)	(4)
A. Ln Savings Deposits by Households:				
Suitability for Cash	0.185*	0.188*	0.180*	0.161
Crops × 1985	(0.100)	(0.106)	(0.102)	(0.123)
Suitability for Cash	0.224*	0.263*	0.270**	0.225*
Crops × Post 85	(0.121)	(0.134)	(0.128)	(0.133)
Observations	5859	5012	4148	5859
Counties	420	359	405	420
B. Ln Investment in Fixed Assets:				
Suitability for Cash	-0.065	0.061	-0.076	-0.047
Crops × 1985	(0.136)	(0.112)	(0.162)	(0.146)
Suitability for Cash	0.318***	0.415***	0.378***	0.302*
Crops × Post 85	(0.104)	(0.077)	(0.122)	(0.170)
Observations	6639	6286	4148	6639
Counties	572	511	405	572
County FE	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes
County Trends				Yes
Data		No Jiangsu	(A)=(B)	

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. All columns other use data from 1965, 70, 78, 85, 90, 95, & 2000-08 and, unless otherwise specified, from counties in Hebei, Jiangsu, Jianxi, Xinjiang & Zhejiang (Panel A) and also from Gansu and Guizhou (Panel B).

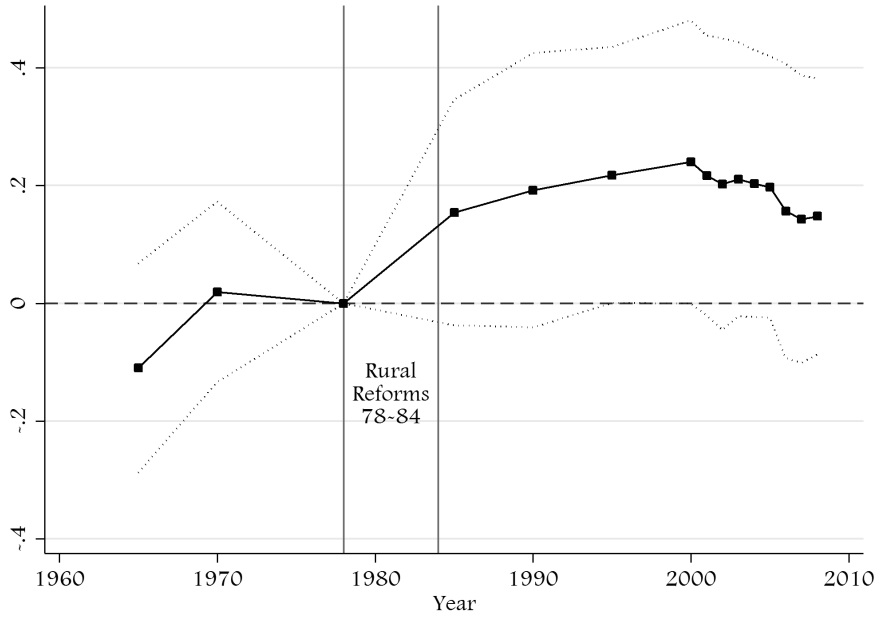


Figure 1.8: Coefficients of 'Year' × 'Suitability for Cash Crops' (dependent variable: Ln Savings Deposits of HH's)

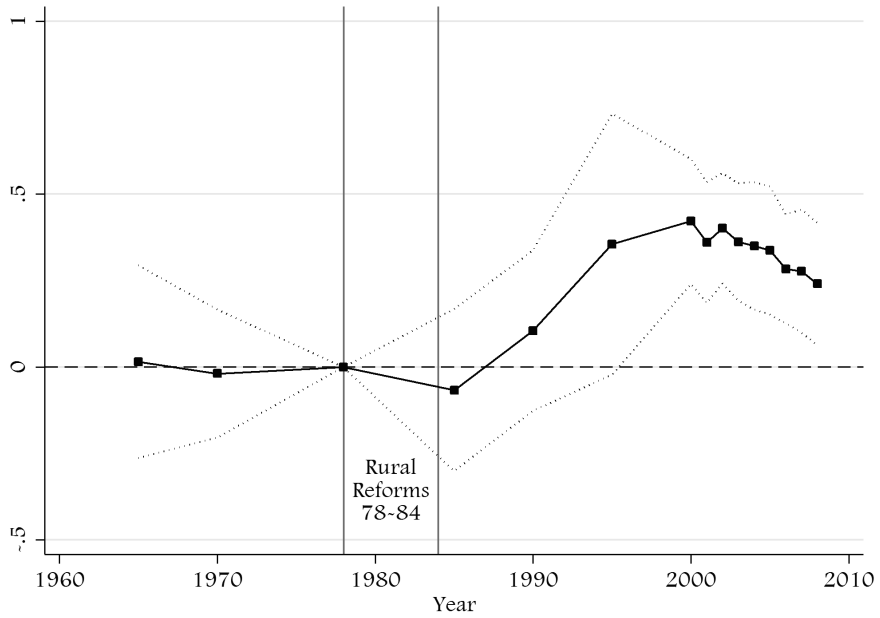


Figure 1.9: Coefficients of 'Year' × 'Suitability for Cash Crops' (dependent variable: Ln Investment in Fixed Assets)

county specific time trends to flexibly control for differential (log) linear trends. In no case do the estimated coefficients change substantively.

1.6.3 How did non-agricultural output increase?

In section 1.2, I outlined three classic channels through which higher agricultural productivity could result in higher non-agricultural output. Under the *labour channel* labour, saving technology improvements reduced the agricultural demand for labour and thus the wage. Under the *demand channel*, increases in rural incomes resulted in higher demand for non-agricultural output. Under the *capital channel*, higher rural incomes increased rural savings and the supply of capital to local firms.

Although the results presented so far are consistent with any of these channels, the institutional details provided in section 1.3 indicated that any increases in non-agricultural output are most likely due to the *capital channel*. In this section I complement the institutional analysis by testing three implications of the model:

1. Linkages through the *labour channel* reduce the share of labour in agriculture;

2. Linkages through the *demand channel* have stronger effects on non-agricultural output in more closed places;

3. Linkages through the *capital channel* result in cheaper capital.

The results of these tests are consistent with the increases in non-agricultural output being primarily due to the *capital channel*.

Agricultural employment shares

If growing cash crops is labour saving compared to growing grain—and non-agricultural output increases through the *labour channel*—the agricultural share of the labour force must decline in areas specialising in cash crops (relative to those suited to grain). As discussed in section 1.3.1, the aggregate data on labour use per hectare indicates that switching to

cash crops probably wasn't labour saving. In this section I use census data to directly test whether the share of labour working in agriculture declined in counties suited to cash crops.

Using the county level tabulations of the 1982, 1990 and 2000 population censuses, I calculate the share of employment in farming, forestry, animal husbandry, and fisheries, henceforth the 'agricultural employment share'.[42] I merge the data from the three censuses, dropping counties with significant border changes.[43] I then regress the agricultural employment share (in percentage points) on my measure of suitability for cash crops interacted with dummies for 1990 and 2000. As always, I include a full set of county and province-time fixed effects, so I am exploiting only using within province variation.

Table 1.11, columns 1-4, contains the results of these regressions. A one standard deviation increase in suitability is associated with a 1.3 to 1.6 percentage point increase in the agricultural employment share between 1982 and 1990. This increase is significant at the 5 percent level.[44] As the estimated increase in the agricultural employment share is obtained using difference-in-differences, the increase is relative to a substantial national decline in the agricultural employment share.

Most of the growth in agricultural output due to specialisation in cash crops had occurred by 1990. In the absence of further gains

[42]Although 1982 is somewhat after the beginning of the reforms they are generally not considered complete until 1984. For instance, in 1981, the Household Responsibility System was in place in 45% of counties, this increased to 80% in 1982. Partial treatment is likely to bias the effect of suitability towards zero as some counties will have already changed their employment practices due to specialisation. However, if suitability was correlated with the roll out of the reforms—in particular HRS—then there may also be additional systematic bias. HRS is thought to have been labour saving and the increases rural incomes resulting from it are likely to have resulted in an expansion of the local non-agricultural sector. Thus if suitability is positively (negatively) correlated with early introduction of HRS, then my estimated coefficients are likely to be additionally biased downwards (upwards).

[43]See appendix A.2 for details of how the data were merged over time.

[44]I report standard errors clustered at the province level. There are 29 provinces so this is fewer than ideal number of clusters. Very similar results with errors clustered at prefecture level are available on request. Results from a two-period first difference specification (i.e. 1982-90 or 1982-00) with wild-bootstrapped clustered SE's (Cameron et al., 2008) are also available and provide very similar results.

Table 1.11: Agricultural Labour Utilisation

	Agricultural Employment Share (0-100%)				*Ln Labour Force*		*Literacy Rate (%)*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Suitability for Cash Crops × Post	1.286**	1.261**	1.625**	1.507**	0.008	0.000	1.109**	1.103**
	(0.603)	(0.574)	(0.600)	(0.552)	(0.008)	(0.007)	(0.484)	(0.459)
Suitability for Cash Crops × 2000	-0.219	-0.265	0.129	-0.130	-0.015	0.049	0.323	0.839
	(0.557)	(0.615)	(0.603)	(0.440)	(0.030)	(0.029)	(0.917)	(0.726)
Observations	6425	6424	6424	6359	6424	6423	6426	6424
Counties	2142	2142	2142	2138	2142	2141	2142	2142
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Controls		Yes	Yes	Yes		Yes		Yes
Initial Labour Share			Yes	Yes				
Drop 'Outliers'				Yes				

Robust standard errors clustered at the province (29) level (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for post 1982 or the year 2000. County controls add additional controls including interactions of initial Ln Population Density, Ln Income Per Capita and Ln Literacy Rate (except columns 7-8). There is a change in the definition of literacy rate between 1982 and 1990. In 1982 it is the share of the population aged over 12 who are literate. In 1990 and 2000 it is the share of the population over 15 who are literate. The comprise the set of Chinese counties in the county level population census data without major border changes between 1982 and 2000. The data also exclude counties in Macao, Hong Kong and Tibet.

from specialisation, there is no reason to expect any further increase in the agricultural employment share. Thus the additional change in the agricultural employment share between 1990 and 2000 provides a pseudo-placebo test of the parallel trends assumption. Consistent with parallel trends, the estimated additional change is statistically insignificant and close to 0. In column 2, I introduce controls for initial income per capita, literacy and population density. In column 3, I also control for the initial share of labour in agriculture. In column 4, I drop extreme values of my outcome variable.[45] The results are robust to all of these changes.

The agricultural employment share increased in counties suited to cash crops, however, if this increase was due to previously discouraged workers entering the labour force, this would not necessarily reduce the supply of labour to the non-agricultural sector. In columns 5 and 6, I that there was no statistically or economically significant difference in growth of the labour force between 1982 and 1990. The absence of differential changes in the labour force is also not indicative of substantial migration or population responses to specialisation in cash crops. I provide additional results on population and migration below.

Although the number of workers in the non-agricultural sector declined in areas suited to cash crops, if the level of human capital increased the number of effective workers need not have declined. The only measure of human capital I observe in a (reasonably) consistent fashion is the literacy rate, which I again obtain from the population censuses.[46] In columns 7 and 8, I provide results indicating that their was a slight relative increase in human capital in areas suited to cash crops; a 1 standard deviation increase in suitability is associated with around a 1 percentage point increase in the literacy rate. This is small relative to the aggregate increase in literacy—between 1982 and 1990 the

[45]Extreme values are the observations yielding the 1% largest squared residuals from a regression of the outcome variable on province-time and county fixed effects.

[46]The literacy rate is based on the population over 12 in the 1982 census and the population over the age of 15 in the 1990 and 2000 census. It is hoped that the increase in literacy due to this definitional change is uncorrelated with suitability for cash crops.

literacy rate increased on average by 9 percentage points and between 1990 and 2000 an additional 14 percentage points. It thus seems unlikely that an additional 1 percentage point improvement in the literacy rate can explain the large increase in output.

These results are inconsistent with the predictions of the *labour channel*, specialisation in cash crops was not labour saving. In the absence of other compensating factors, non-agricultural output would have fallen as it did after the introduction of high yielding rice varieties in Foster and Rosenzweig (2004) and genetically modified maize in Bustos et al. (2014).

'Openness'

If higher agricultural output increased non-agricultural output through the *demand channel*, the increases would have been stronger in less open places where higher demand could not easily be satisfied with imports. Because counties are small, and thus fairly open, then the effect of the demand channel is *a priori* likely to be limited. Nevertheless, I test this directly using two proxies for 'openness', distance from either Historic Cities or International Airports in 2007.[47] Clearly the location of International Airports in 2007 is endogenous to growth, however their locations capture most of China's major cities.[48] The locations of Historic Cities was determined at least 60 years before the reforms—and are thus plausibly exogenous to post reform growth—but provide a less complete description of the set of important cities. In either case, the idea is that places closer to large cities, such as suburban counties of Shanghai, are more open to trade in goods than isolated areas, such as rural Xinjiang.

Table 1.12 contains the results. Qualitatively similar estimates are obtained regardless of whether the proxy is distance to historic cities or distance to contemporary airports. Reassuringly the direct effect of distance is negative—more isolated counties grew more slowly after the reforms. The sign on the interactions, our variables of interest, is also

[47] For a description of this data see appendix A.2.

[48] Additional results for seaports are available on request.

negative and, for historic cities, statistically significant. If anything, positive linkages between the agricultural and non-agricultural sectors were *stronger* in more open counties. This is the opposite of what one would expect if induced demand was the primary channel linking the agricultural and non-agricultural sectors.[49]

Interestingly, while if linkages to the non-agricultural were *only* through the demand channel we would expect them to be stronger in more closed economies, if linkages were through both demand *and* capital channels they could be stronger or weaker. Because capital is used in the non-agricultural sector, an increase in the supply of capital increases non-agricultural output. In an open economy this has no effect on relative prices, but in a closed economy, this increase causes the relative price of non-agricultural output to fall and diverts labour to the agricultural sector. Depending on the size of this effect, non-agricultural output growth can be slower in a more closed economy despite the presence of linkages through the demand channel.

Factor prices and factor utilisation

The institutional details provided in section 1.3 suggested that any increases in non-agricultural output would most likely be due to the *capital channel*. The results in the previous two subsections have been consistent with this, the increases do not appear to have been due to specialisation in cash crops being labour saving, or increasing the demand for locally produced non-agricultural output.

In the *capital channel*, higher agricultural output increases savings and decreases the cost of capital. In section 1.3.2, I argued that only non-state firms raised capital locally, while state-owned firms had access to national capital markets. Thus, we should expect the cost of capital to

[49]It is worth noting that there is no differential effect of suitability with distance on agricultural output so the differential effect by distance is not due to differences in the size of the shock to agricultural surpluses. These additional results are reported in appendix table A.5.

Table 1.12: Openness Interactions

	Ln Non-Primary GDP		
	(1) OLS	(2) OLS	(3) IV
Suitability for Cash Crops (SCC) × 1985	0.032	0.083**	0.050
	(0.041)	(0.037)	(0.049)
Suitability for Cash Crops (SCC) × Post 85	0.189***	0.253***	0.211***
	(0.065)	(0.069)	(0.065)
Ln Distance to Nearest Airport × 1985	-0.143**		-0.192**
	(0.059)		(0.095)
Ln Distance to Nearest Airport × Post	-0.212***		-0.221*
	(0.065)		(0.129)
Ln Distance to Nearest Airport × SCC × 1985	-0.043		-0.140*
	(0.047)		(0.080)
Ln Distance to Nearest Airport × SCC × Post 85	-0.079		-0.178*
	(0.053)		(0.092)
Ln Distance to Nearest Historical City × 1985		-0.113**	
		(0.049)	
Ln Distance to Nearest Historical City × Post 85		-0.130*	
		(0.071)	
Ln Distance to Nearest Historical City × SCC × 1985		-0.071**	
		(0.032)	
Ln Distance to Nearest Historical City × SCC × Post 85		-0.088*	
		(0.052)	
Observations	7993	7993	7993
Counties	561	561	561
County FE	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Time interaction terms are dummies for 1985 or years after 1985. Distance interactions are (demeaned) ln crow flies distance to nearest airport or nearest historic city. In column 3, distance to nearest international airport and the various interactions are instrumented for by distance to nearest historical city. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

fall primarily for non-state firms. (State-owned firms may, however, face higher wages.)

Unfortunately, I do not directly observe the factor prices faced by firms. However, by assuming a production function, I can obtain an expression which allows factor prices to be inferred from a firm's total wage bill wl and capital utilisation k, both of which I do observe.[50] Suppose a price taking firm has a CES production function, with elasticity of substitution σ, and the weight on labour α, then, obtaining conditional factor demands, rearranging and taking logs, provides the following expression for factor utilisation

$$\ln\left(\frac{wl}{k}\right) = \sigma \ln\left(\frac{1-\alpha}{\alpha}\right) + \sigma \ln(r) + (1-\sigma)\ln(w) \tag{1.15}$$

which says that the ratio of the wage bill to capital is increasing in the rental rate. Furthermore, if $\sigma > 1$ it is also decreasing in the wage. Recent estimates for China (Karabarbounis and Neiman, 2014) and Chinese firms (Berkowitz et al., 2014) suggest that σ is indeed significantly greater than 1. Consequently, if counties suitable for cash crops experienced an increase in the demand for labour (increasing the wage) but also an increase in the supply of capital for non-state firms (reducing their rental rate), then all firms located in these counties ought to use relatively more capital, but non-state firms especially so.

I test this using the firm level data from the 1995 Industrial Census. For each firm, I calculate the ratio of labour costs (wages + welfare expenses + labour and unemployment insurance) to the value of fixed capital net of depreciation. I then estimate variants of the following equation

$$\ln\left(\frac{wl}{k}\right)_{ijk} = \gamma_{jk} + \beta_1 SOE_i + \beta_2(SCC_i \times nonSOE_i) + \beta_3(SCC_i \times SOE_i) + \epsilon_{ijk}$$

[50] My data do not contain information on l, however due to unobserved heterogeneity in worker quality, the use of wl may be preferable anyway.

where SOE_i and $nonSOE_i$ are dummy variables taking a value of 1 if firm i is a state owned or non-state enterprise respectively. SCC_i is the suitability for growing cash crops of the county in which the firm is located. γ_{jk} is a province-by-industry fixed effect, which allows for the weight on capital (α) in the production function to vary by provinces and industry. The inclusion of these fixed effects means that, in my least demanding specification, I am only using variation in suitability between firms in the same province *and* in the same 4 digit industry. Providing firms; (1) have the assumed CES production function, and; (2) that α is not correlated with suitability for cash crops other than through factors contained in the fixed effect, then β_2 and β_3 capture differences in factor prices.

Table 1.13 contains the results. For non-state firms, a one standard deviation increase in suitability is associated with a reduction in the ratio of total wages to capital of 8%. This is significant at the 1 percent level. The point estimate for state owned firms is much smaller, indicating a fall in the wage-capital ratio of 3%, and is statistically insignificant. By way of comparison, state owned firms are found to have a total wage to capital ratio 33% lower than non-state firms in the same industry, which is consistent with the lower cost of capital they are known to face. Reassuringly, the estimated coefficients are stable in the face of much more demanding fixed effect specifications and to the trimming of extreme capital labour ratios.

These results are consistent with all firms facing higher wages and non-state firms facing cheaper capital in counties suitable for cash crops. This is the pattern of factor prices expected if specialisation in cash crops increased the agricultural demand for labour and the supply of capital to non-state firms. As with the results on the share of labour working in agriculture, they are not indicative of specialisation reducing the demand for agricultural labour (which would be expected to reduce the wage).[51]

[51]These results, although not those on the share of labour in agriculture, are consistent with labour saving agricultural technology improvements if $0 < \sigma < 1$.

Table 1.13: Firms Factor Utilisation

	$\ln(\frac{wl}{k})$			
	(1)	(2)	(3)	(4)
Suitability for Cash Crops × non-SOE	-0.076***	-0.077***	-0.063***	-0.056***
	(0.019)	(0.018)	(0.021)	(0.020)
Suitability for Cash Crops × SOE	-0.026	-0.033	-0.022	-0.017
	(0.030)	(0.033)	(0.031)	(0.028)
State Ownership	-0.421***			
	(0.055)			
Firms	384167	384167	384167	376905
Prov × Industry FE	Yes			
Prov × Industry × SOE FE		Yes		
P × I × SOE × Large × Age FE			Yes	Yes
Trimmed (1-99)				Yes

Robust standard errors clustered at the province (30) level (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop for the county where the firm is located. The data covers all manufacturing firms with independent accounting systems in 1995. I exclude firms from Tibet, Macao, Hong Kong, cities whose metropolitan areas cover more than one district (about 200 counties in total) as well as firms with clear data irregularities. Industry is the 4 digit Chinese SITC classification. I restrict the set of firms to those with strictly positive gross output, wages and capital. For the purpose of the fixed effects, 'Large' firms are firms with sales revenues in excess of 5 million Yuan. 'Age' groups firms by age into 6 categories: 0-1, 2-5, 6-10, 11-16, 17-25 and 26+. Trimmed (1-99) indicates that the first and last percentile of the outcome data has been omitted.

1.6.4 From county to national level linkages

As these results are obtained using county level data it is natural to ask what we learn about the effect of the reforms at a national level. It is unclear whether aggregate linkages would be stronger or weaker than the ones identified for counties. In spite of geographic capital market frictions, it is inevitable that some capital will have leaked out of counties and so we might expect stronger linkages. Similarly, at the national level higher agricultural output could increase non-agricultural output by increasing the demand, as it does in the closed economy models of structural transformation of Echevarria (1997), Kongsamut et al. (1997) and Ngai and Pissarides (2007). On the other hand, the counties in my sample are significantly more rural than China as a whole and the elasticity of non-agricultural output with respect to agricultural output may be quite different when agriculture is 25% of output rather than 50%. It has also been suggested that early growth in non-state output provided a beneficial first mover advantage by allowing firms to use early monopoly profits to build up a stock of capital (Naughton, 2007). If this were the case, at least some of the identified effect would merely be a reallocation of output across space. Given the high returns to capital observed for non-state firms in China, and the observed increase in savings, it seems unlikely that this explains all the observed effect.

Relatedly, because the increases in agricultural output here are due to specialisation they do not directly speak to the effect of increases in agricultural output due to decommunalisation. While decommunalisation is also likely to have increased rural savings, the effect on agricultural demand for labour may have been quite different. Indeed, Taylor (1988) finds that the number of days worked per hectare of rural land fell by an average of 30% after the decommunalisation of agriculture—increases in agricultural output due to decommunalisation may have been labour saving. If they were, forward linkages from the decommunalisation of agriculture will have been stronger than the linkages due to specialisation.

1.6.5 Migration and population

As discussed in section 1.3, the *hukou* system significantly restricted labour mobility in China, particularly before the end of grain rationing in 1994. However, if in spite of this there was substantial migration to counties suitable for growing cash crops, the interpretation of my results would be quite different. In particular, the results would be much less likely to indicate an overall increase in output, and more likely to indicate a reallocation of output across space. We saw in section 1.6.3, that there was no differential change in the size of the labour force. Furthermore, if there had been substantial migration, we might expect capital to be relatively expensive in counties suited to cash crops. The results of section 1.6.3 indicated capital was relatively cheap. In this section I provide three additional pieces of evidence indicating limited migration. First, I show that individuals living in counties suited to cash crops were no more likely to have been migrants in 1990 than individuals in counties suited to grain. Second, I show that counties suited to cash crops had similar post-reform growth in population (although by 2008 their population had increased somewhat relative to counties suited to grain). Third, I control directly for population in my main regressions.

Migration

The 1990 Population Census includes a question on where each individual lived in the middle of 1985. I use this question to divide the 1% sample into 'migrants' and 'non-migrants'. I then assign each person the suitability for cash crops of the county they live in. To test whether there are relatively more migrants in areas suited to cash crops I regress migrant status on suitability. Table 1.14 contains the results. Column 1 indicates that migrant status and suitability are essentially uncorrelated. Columns 2 and 3 introduce province fixed effects, and then individual level controls for age, education status and gender—migrant status and suitability remain uncorrelated. According to the 1990 census, their is no relationship between migrant status and suitability for cash crops.

Table 1.14: Migration

	Migrant Dummy		
	(1)	(2)	(3)
Suitability for Cash Crops	-0.006	0.004	0.002
	(0.006)	(0.006)	(0.005)
Individuals	10.5m	10.5m	10.5m
Province FE		Yes	Yes
Individual Controls			Yes
Migrant Share of Population	0.034	0.034	0.034

Robust standard errors clustered at the province level (*** p<0.01, ** p<0.05, * p<0.1). Data from 1990 census micro-data. Migrant Dummy takes a value of 1 if individuals place of residence in mid-1985 was not their current place of residence in the 1990 census. Individuals who don't report a place of residence in 1985 are excluded (primarily children under 5). Individual controls are 'Year of Birth', a set of dummies for 7 education levels (Illiterate or semi-literate, Primary school, Junior middle school, Senior middle school, Technical school, Junior-college, and University) and a dummy for gender.

Population

The absence of differential migration in the cross-section does not necessarily mean there were no differential changes in migration over time. It is algebraically possible that increased in-migration was perfectly offset by a decreased out-migration. This would result in more rapid population growth. My main dataset contains a measure of population based on a mixture of surveys and *hukou* registrations. However, because there are barriers to changing *hukou* registration (although these are less severe for rural-rural migration which we are primarily concerned with here), this measure probably undercounts migrants. So, as a complement to the official measure of population, I create an alternative measure, 'imputed population', by dividing GDP by GDP per capita. As both GDP and GDP per capita explicitly include the economic activity of all migrants, imputed population should capture fully capture their numbers (Desmet and Rossi-Hansberg, 2013). I test for differential

population growth using both the raw measure of population and imputed population.

Table 1.15 provides the results. A one standard deviation increase in my measure of suitability is associated with 5% higher population or 8% higher imputed population from 1990-2008 (columns 1 and 3). These are small increases relative to the observed increases in agricultural and non-agricultural output in my baseline results. These results are not robust to the inclusion of county specific time trends (columns 2 and 4) which suggests that the increases observed may reflect modest differential trends in population growth.

Because the result indicate a modest population response, in columns 5-8 I reestimate my main results directly controlling for my measures of population. The coefficients on suitability are, if anything, slightly larger than in my baseline specification. The increase in output in counties suited to cash crops was not due to differential population growth. As one would expect, the measures of population provided directly in the yearbooks are associated with higher agricultural and non-agricultural output. Surprisingly though, the coefficients on imputed population are close to 0 and statistically insignificant. Given that these measures are supposed to better capture migration we might have expected larger coefficients, especially as the two measures of population are highly correlated. It is possible that the procedure for inferring population in this way introduces additional error in the population figures, and that the accompanying attenuation bias more than offsets the benefit of counting migrants.

1.6.6 Other explanations

The results of the large number of robustness checks previously discussed suggest that the results are unlikely to have be driven by some other correlated shock. However, it is possible that areas that specialised in cash crops, were better placed to benefit from other reforms *due to their specialisation in cash crops*. Given the institutional details discussed

Table 1.15: Population

	Ln Population		*Ln Pop (Imputed)*		*Ln Primary GDP*		*Ln Non-Ag GDP*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Suitability for Cash Crops × 1985	-0.003	-0.022	-0.005	-0.040	0.180***	0.171***	0.032	0.047
	(0.019)	(0.019)	(0.026)	(0.030)	(0.058)	(0.051)	(0.034)	(0.034)
Suitability for Cash Crops × Post 85	0.047**	-0.005	0.081**	0.001	0.239***	0.278***	0.168**	0.215***
	(0.023)	(0.021)	(0.041)	(0.032)	(0.070)	(0.057)	(0.071)	(0.070)
Ln Population					0.395***		0.575***	
					(0.148)		(0.186)	
Ln Population (Imputed)						0.057		0.126
						(0.127)		(0.178)
Observations	8984	8984	6859	6859	7813	6491	7806	6491
Counties	621	621	588	588	559	527	559	527
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Trends		Yes		Yes				

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Imputed population is the population of a county when it is inferred from GDP and GDP per capita i.e. $ImputedPopulation_i = GDP_i/GDPpc_i$. Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and Changzhi prefecture (Shanxi) 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008. Columns 1-4 also use data from counties in Jiangsu. Columns 1, 2, 5 & 6 also use data from Chengdu (Sichuan) and Linfen (Shanxi) prefectures.

in section 1.3.4 two possibilities seem particularly worthy of further explanation.

Political favouritism and state-owned output

First, because the state-owned sector produced more than half of China's industrial output until 1998 (although likely a smaller share of services and construction), it's production remained important. Furthermore, although the importance of profits in the state owned sectors objective function increased through the 1980's and especially from the early 1990's onwards, the sector as a whole was still under political control. Because of this, it is possible that the growth in non-agricultural output ended up being in counties suited for cash crops for political reasons; perhaps as a reward to local leaders for good performance in the agricultural sector. In this case, my results would overstate the strength of linkages. (The converse is also possible; the state owned sector could have been used to equalise incomes across space and my results would understate the true strength of the linkages.)

Given the state's power over SOEs, we would expect any political favoritism to manifest through increases in state owned output. (Whereas because only non-state firms are forced to raise capital locally, increases through the supply of capital would be expected to increase the output of the non-state sector.) Unfortunately, I do not observe a breakdown of output over time by ownership type at a disaggregated level. However, using the 1995 industrial census, I can create a measure of firm entry over time at the county level; albeit one for which survivor bias may be problematic.

The 1995 Industrial Census records the founding date of firms. I use this to count the number of (surviving) State and non-State firms started pre-reform (1966-1978) and post-reform (1979-1995) in each county.[52] I then use this data to test whether counties with a comparative advantage

[52]Changing the definition of 'pre' and 'post' does not significantly change the results. The first year of the 'pre' period (1966) was chosen as it was the start of the cultural revolution.

in cash crops experienced differential growth of entry of (surviving) firms after the reform. The estimating equation is

$$\Delta Y_{ivk} = \alpha_{jv} + \beta_1(SCC_i \times nonSOE_{ik}) + \beta_2(SCC_i \times SOE_{ik}) + \epsilon_{ijk}$$

where α_{vk} is a province-by-ownership type fixed effect allowing for differential growth in the number of firm starts at the province level for State and non-State firms; SCC_i is my measure of suitability; and, SOE_{ik} is a dummy taking a value of one for observations relating to the growth of State owned firm starts. The first is the difference in log firm starts in the State or non-State sector before and after the reform.[53] Because there are a number of zeros in the data, the second is a dummy variable taking a value of 1 if the growth in firm starts is above the median.[54] The errors are clustered at the province level to allow for spatially correlated errors Because of the relatively small number of clusters, I also provide wild-bootstrapped p-values.

Table 1.16 contains the results. Areas suited to cash crops cash crops have a relative decrease in the number of State-owned firms entering after the reforms. The number of non-State firm starts increases, albeit by a statistically insignificant amount. The problematic nature of creating a panel of firm entry data using only surviving firms mean we must be careful not to over interpret the results. Nevertheless, the relative decline in entry of state-owned firms is not indicative of counties suited to cash crops benefiting from substantial political patronage.

These results on firm entry also provide weak evidence against the idea that producing cash crops may have provided experience of an entrepreneurial activity and awakened the 'spirit of capitalism' in counties suited to their production. If this were the case, we would perhaps have expected to see a surge of entry of non-state firms in

[53] I.e. an observation would be $Y_{ivk} = \ln(STARTSPOST_{ivk})$-$\ln(STARTSPRE_{ivk})$ where i is the county, v is the province and k is the type of firm (either state or non-State).

[54] In the calculation of growth in firm starts, when there are no firm starts in either period I code growth as 1 while when there are 0 starts in the first period and a positive number in the second the growth in starts is top coded. This provides a figure for growth in starts for all counties.

Table 1.16: Entry of Firms

	$\Delta \ln(NewFirms)$	$New\ Firms > Median$
	(1)	(2)
Suitability for Cash Crops	0.022	0.004
× non-SOE × Post	(0.064)	(0.031)
	[0.736]	[0.876]
Suitability for Cash Crops	-0.077	-0.069**
× SOE × Post	(0.047)	(0.027)
	[0.106]	[0.050]
N	4002	4206
Province × SOE FE	Yes	Yes

$\Delta Ln(NewFirms)$ is the log difference in the number of surviving firms started post-reform compared to the number started pre-reform. The 'More Firms Starts Dummy' is a dummy variable taking a value of 1 if the percentage increase in firm starts was above the median for firms of that ownership type. Counties with 0 firms starts both pre and post-reform are assigned a growth of 1. Counties with no firm starts pre-reform and a positive number post reform are assigned the maximum growth in firms starts. Pre-reform is the cultural revolution era 1966-1978, post-reform is from 1979-1995. The data cover the whole of China China except for Tibet, Hong Kong, Macau and municipal areas that span more than one county level administrative unit (around 200 counties). Robust standard errors clustered at the province (30) level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Wild-bootstrapped p values in square brackets

the years following the reforms. However as we might have expected cheaper capital to also have increased the entry of non-state firms, and yet minimal additional entry is observed, this is hardly conclusive.

Learning by doing, textiles and downstream industries

The first sectors to be opened up to non-state firms were agricultural processing sectors. These early agricultural processing firms were quickly followed by firms in downstream industries. Given the importance of the textile and garment industry in reform era China, one might worry that these firms ended up overwhelmingly locating in areas relatively suited to cash crops. Then, either learning by doing in textiles or experience in manufacturing could have resulted in this initial advantage multiplying.

If this were the case, we would expect firms in cotton and oilseed processing and downstream industries to be located in counties suited to cash crops. Although I cannot observe the output of specific industries over time, the 1995 industrial census provides a post-reform snapshot. For each county I calculate the sum of sales of firms located in industries which are downstream of cotton and oilseeds—the cash crops used to calculate my measure of suitability.[55] I divide this by the sum of all sales of firms in that county, to calculate the share of a county's manufacturing firms sales that are of cash crop derivatives. Table 1.17, column 1, indicates that the share of manufacturing output in cash crop processing industries is higher in counties with land more suited to cash crops. These important sectors are located close to their raw materials.[56]

Note, however, that while my measure of suitability gives the relative productivity in cash crops, which is likely to be the key determinant of the farmers planting decision, it is only partly related to the absolute productivity, which will be an important determinant of the local availability of large quantities of agricultural inputs. In column 2, I show that (log) absolute productivity in cash crops is also a strong predictor of the location of cotton and oilseed processing industries. In fact, when you allow for both absolute productivity and my measure of suitability only absolute productivity is predictive of the location of firms (column 3). Thus, if my results are driven by places relatively suited to cash crops enjoying access to inputs in the earliest years of the reforms and a corresponding first mover advantage, we would expect absolute productivity to also strongly predict non-agricultural output growth.

Columns 4-6 indicate that in fact it is suitability for cash crops, i.e. relative productivity, rather than absolute productivity, which is predictive

[55] Cotton and oilseed processing sectors are 1321 Edible Vegetable Oil, 1322 Inedible Vegetable Oil, 1322 Inedible Vegetable Oil, 1454 Seasoning Oil, 1711 Cotton Ginning 1721 Cotton Spinning, 1722 Cotton Weaving, 1723 Cotton, Printing and Dyeing, 1724 Cotton Products, 1725 Cotton Thread, 1726 Cotton Cord Fabric, 1729 Other Cotton Goods, 1781 Cotton Knitwear.

[56] Because the data is right skewed and there are a large number of counties which produce no cash crop derivatives, I estimate this relationship using a pseudo-Poisson Maximum Likelihood estimator. The coefficients are semi-elasticities.

Table 1.17: Geographical Concentration of Cash Crop Processing

	Share of Cash Crop Processing in manufacturing output			*Ln Non-Agricultural GDP*		
	Pseudo Poisson-MLE			OLS (FE)		
	(1)	(2)	(3)	(4)	(5)	(6)
				Baseline		
Suitability for Cash Crops (Relative)	0.566***		0.279			
	(0.184)		(0.228)			
Ln Absolute Yield in Cash Crops		1.368***	0.824**			
		(0.356)	(0.388)			
Suitability for Cash Crops (Relative) × 1985				0.022		0.074
				(0.031)		(0.052)
Suitability for Cash Crops (Relative) × Post 85				0.181**		0.218**
				(0.072)		(0.097)
Ln Absolute Yield in Cash Crops × 1985					-0.037	-0.080
					(0.041)	(0.053)
Ln Absolute Yield in Cash Crops × Post 85					0.089	-0.057
					(0.070)	(0.082)
Counties	2104	2101	2101	561	561	561
N				7993	7993	7993
Province FE	Yes	Yes	Yes			
County FE				Yes	Yes	Yes
Province x Year FE FE				Yes	Yes	Yes

Columns 1-3 estimated using pseudo-Poisson regressions due to the skewness of the outcome and large numbers of zeros in the data. Robust standard errors clustered at the province (30) level in columns 1-3 and two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space columns 4-6 (*** p<0.01, ** p<0.05, * p<0.1). 'Suitability for Cash Crops' is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop for the county where the firm is located. 'Suitability for Cash Crops (relative)' is my baseline measure of suitability. It is the (standardised, county average) value of the yield of the best cash crop per hectare. The outcome variable in columns 1-3 uses the 1995 Industrial Census, to calculate county-specific sums of sales of firms in sectors whose major inputs are cash crops e.g. 1711 'cotton ginning' or 1454 'seasoning oil', and divides it by the sales of all firms. Thus, the outcome will be higher in counties which are relatively specialised in processing cash crops. The list of sectors deemed to be cash crop processing is provided in footnote 55 (appendix section A.3.2). Columns 4-6 use my main data set covering non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

of subsequent growth. Column 4 restates by baseline results. Column 5 includes only absolute productivity; absolute productivity at best weakly predicts subsequent non-agricultural output growth. Column 6, includes both suitability for cash crops and absolute productivity. Only suitability positively predicts subsequent growth in this specification. Given that firms in industries directly downstream from cash crops are clustered primarily in locations with high absolute productivity, it seems unlikely that the early opening is responsible for the rapid growth of counties suited to cash crops.

1.7 Conclusion

Chinese reforms beginning in 1978 have been described as being perhaps responsible for 'the greatest increase in economic well-being within a 15-year period in all of history' (Fischer, 1994, p. 131). In this chapter I have shown that successful reforms to the agricultural sector had positive and long-lasting forward linkages to the non-agricultural sector in the early reform era. I exploited the predictions of a simple theoretical model, and several supplementary data sources to provide evidence that the linkages identified were primarily due to higher agricultural surpluses increasing the supply of capital to non-state firms.

In China, high savings rates were an important factor in China's reform era growth, and because of the large size of the agricultural sector in the early 1980's rural savings made possible by larger agricultural surpluses were likely an important part of this. The importance of savings—of which rural savings must be an important part in primarily agricultural economies—was central to classic models of growth such as the Lewis or Harrod-Domar models, but has since fallen out of favour. Indeed, Easterly and Levine titled their 2001 review of the empirical growth literature 'What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation'. The results of this chapter suggest that it sometimes *is* capital accumulation. In this respect, it complements a growth accounting literature that finds that much of

the growth in many fast growing East Asian economies can in fact be explained by capital accumulation (Kim and Lau, 1994; Young, 1995; Collins and Bosworth, 1996; Young, 2003). Interestingly, many of these countries including Japan, Korea, Taiwan and Vietnam, also undertook successful agricultural reforms around the start of their periods of rapid growth. In each of these cases, agricultural surpluses may have been an important source of capital for the non-agricultural sector.

While enormous progress has been made in understanding the effectiveness of specific development interventions, less progress has been made in understanding what happens as an economy begins to industrialise. This chapter took an applied micro approach to a macro-development question. By exploiting specific features of Chinese institutions, a simple model of linkages, and a range of supplementary evidence, I was able both to identify positive linkages and understand why these linkages occurred. The chapter highlights the benefits of having spatially disaggregated data, which increases the number of observations without blowing up the number of confounders as country level data would, as well as a theoretically motivated set of additional empirical tests to disentangle the mechanism. The rich county level data used in this chapter is also likely to be valuable for future empirical work, and highlighting the existence of this data provides an additional contribution.

Chapter 2

Rural Incomes and Urban Development: Evidence From China

Since 1978, the urban population of China has increased by more than 300 million people. This chapter asks how rapid rural income growth in the 1980's affected this urbanisation. In a simple model the effect is ambiguous. On one hand, higher agricultural productivity increases the returns to farming. On the other, higher rural incomes increase the demand for urban non-tradables such as entertainment, business services and public administration. Exploiting plausibly exogenous variation in agricultural productivity provided by China's agricultural reforms, I show that, at the local level, the latter effect dominates, and higher rural incomes increase urbanisation between 1978 and 1995. Furthermore, because long distance migration was heavily curtailed, higher local urbanisation primarily captures movement from the nearby countryside and not from elsewhere—indicating a real increase in urbanisation and not just a reallocation of urban areas across space. Consistent with higher rural incomes increasing the demand for urban non-tradables, cities in areas where agricultural incomes increased became more specialised in service sector output.

2.1 Introduction

China's dramatic development began with highly successful agricultural reforms. These reforms increased agricultural output, rural savings and transformed China into a net exporter of agricultural goods. At the time of the reforms, more than 80% of China's population lived in the countryside, but by sometime in 2011 fewer than 50% did—the urban population had increased by more than 10 million people per year since 1978.[1]

At the same time, China was industrialising rapidly. At first, industrial development was concentrated in rural areas—the Township and Village Enterprise phenomenon—however, since the mid 1990's cities and their suburbs have provided much of the impetus. Perhaps not coincidentally, the rise of China's cities is mirrored in the rise of the service sector in China's economy. In 2012, just one year after China became majority urban for the first time, services became the largest sector of the economy. This chapter asks how improvements in agricultural productivity and rural development, the two most important phenomena of the early reform-era, shaped one of it's most important ongoing phenomena: urbanisation.

Despite rapid urbanisation, China is still relatively rural for its level of development (Taylor et al., 2003; Au and Henderson, 2006a). Although, internal migration restrictions undoubtedly increased the cost of migration, the nature of China's early reform-era growth may also have played a role in slowing urbanisation. Initial reforms liberalised agriculture and rural industry, and for around the first decade or so, gaps between rural and urban incomes declined.[2] To the extent that migration

[1] Figures in introduction based on National Bureau of Statistics (NBS) provided by the University of Michigan's China Data Center. Population statistics may undercount urban populations due to the use of official registration data.

[2] The ratio of urban to rural consumption declined from around 3 in 1978 to just over 2 in 1990 before rising sharply thereafter and exceeding the 1978 ratio by 1993. Although not strictly comparable with each other, ratio's of Net Rural Income to Urban Disposable Income display a similar pattern and trough between 1983-85 and exceed their 1978 levels by 1992. (Source: Calculations Based on NBS Data.)

flows respond to rural urban income gaps (Harris and Todaro, 1970), then rural income growth due to increased agricultural productivity will have reduced migration and slowed urbanisation.

On the other hand, higher rural incomes could have led to increased demand for manufactures and services, the production of which are often thought to benefit from the forces of agglomeration and hence be concentrated in cities. Indeed, in a simple model of urbanisation and structural transformation closely related to that of Gollin et al. (2013), the effect of agricultural productivity growth is the net of these forces, with higher rural wages diverting labour from urban tradable sectors, and higher demand for urban non-tradables increasing urbanisation. Whether rural development promotes urbanisation is thus an empirical question.

Exploring the relationship between rural development and urbanisation in the context of China has both intrinsic and methodological benefits. The sheer scale of things provides particular economic and historical interest. Because Chinese growth has many parallels to that of other fast growing East Asian economies including South Korea, Japan, and particularly, Vietnam and Taiwan, any lessons learned will be of particular relevance to understanding urbanisation across East Asia. Finally, because the economic forces studied are relatively generic, the results are likely to be of relevance whenever agriculture can have a significant impact on the structure of the economy.

Methodologically, China's large size, relative homogeneity, and highly disaggregated data makes it an appealing place to do empirical work. These features allows me to produce consistent data for nearly 50 'cities' and their accompanying hinterlands over a thirty year period.[3] Migration restrictions and low levels of migration, especially over long distances and particularly up until the mid 1990's, aid in the interpretation of

[3]I use a definitions of 'cities' and hinterlands closely related to that of Baum-Snow et al. (2012). I define the 'city' to be the administrative county or district (sometimes districts) of the prefecture, while hinterlands are the governed county level administrative divisions. A prefecture is the administrative unit between the province and the county (which themselves are more or less equivalent to US states and counties). The data is discussed in more detail in section 2.4.1.

the results; when we see a city growing, we can be relatively confident that the new residents were drawn from the surrounding countryside. (Because of this, my analysis focusses on the 30 year period from 1965 to 1995—before the era of mass migration.) In addition to this, geographic frictions in China's capital markets keep local shocks local and limit the extent to which positive shocks to one sector crowd out activity in another.[4] Finally, China's agricultural reforms provide a plausibly exogenous source of long lasting variation in output growth, which allows me to overcome the pervasive endogeneity associated with linking rural incomes, industrialisation and urbanisation.

China's agricultural reforms decommunalised agriculture and liberalised the planting of cash crops. To provide variation in rural incomes, I exploit the latter. I identify areas relatively suited to cotton and oilseeds (the main cash crops in China in the early 1980's) using high resolution data on theoretical crop yields from the Food and Agriculture Organisation's Global Agro-Ecological Zones database.[5] Then, I use this cross-sectional variation, combined with the timing of the reforms to estimate the effect of rural development of China's patterns of urbanisation.

In addition to variation in the size of the shock to rural incomes, I am also able to exploit the difference between administrative organisation in different regions of China. In my data, cities are the set of central city districts (*shixiaqu*) or, for prefectures without a *shixiaqu*, the county containing the prefectural administration. In Western China, these areas tend to be quite large, and although they are more urban and more developed than their hinterlands, the difference is less pronounced than

[4]See e.g. Boyreau-Debray and Wei (2005); Bai et al. (2006); Dollar and Wei (2007); Naughton (2007); Banerjee et al. (2012) or Chapter 1.

[5]Nunn and Qian (2011) pioneered the use of this data in this type of context in their study exploring the introduction of potatoes to the old world. Chapter 1 has shown that counties relatively suited to these crops enjoyed large sustained relative increases in agricultural, and later non-agricultural, output in China. One additional benefit to the increase in rural incomes used here, is that it cannot affect urbanisation through increasing the local supply of food, as increases in agricultural productivity have sometimes done so historically (Nunn and Qian, 2011)

in Eastern China. Thus, if the effects observed are due to the effect of higher incomes on urban development, rather than say the link between higher rural incomes and the size of the local bureaucracy, then we should expect weaker linkages in Western China. Hence, Western China provides a quasi-placebo test of the mechanism.

The first set of results consider the effect of higher rural incomes on the pace of urbanisation. Because migration across prefectural boundaries is difficult, the share of the population living in the central 'city' is an appropriate measure of urbanisation. A simple model suggests two offsetting effects of an increase in agricultural productivity. Higher agricultural productivity could increase rural incomes relative to urban ones, reducing the incentive to migrate. However, if higher incomes resulted in movement along the Engel curve, and an increase in the demand for city produced services, we would expect urbanisation to increase. The results suggest the latter effect dominates. Prefectures with larger increases in agricultural productivity become relatively more urban. However, in spite of the increase in urbanisation, and consistent with the improvement in agricultural productivity having a significant impact on rural output, the share of output produced by the urban core declines. Reassuringly these effects are much weaker in Western China, which is consistent with the differences in administrative organisation.

The second set of results considers the effect of higher incomes on the composition of urban output. In parts of China where rural incomes grew faster, the tertiary share of output increases at the expense of secondary output. On the assumption that services are less tradable than industrial output, this finding is consistent with an increase in the demand for city produced non-tradable services, and the predictions of the simple model of urbanisation and structural change provided. As with urbanisation, the effect is almost entirely due to non-Western China.

By contrast, in rural areas, there is little effect on the composition of output (although the primary share may increase somewhat at the expense of secondary industry). This is consistent with the results of Chapter 1, which demonstrated that there were substantial positive

linkages between agriculture and other sectors of the economy at a local level thanks to higher agricultural surpluses increasing the supply of capital to early non-state firms.

Although China has substantial geographic capital and labour market frictions, Chinese prefectures are still relatively open to trade in goods. Lower trade costs increase the substitutability of agricultural production and urban manufacturing, suggesting that the results here, based on subnational data, may understate the impact agricultural productivity on the national urbanisation rate and overstate the changes to the national composition of urban output.

This chapter is most closely related to a number of recent papers exploring the joint impact of urbanisation and structural transformation. Jedwab (2013) and Gollin et al. (2013) have respectively explored the consequences of higher resource rents within West African countries and cross nationally. As with improvements in agricultural productivity here, they find that resource rents promote cities that specialise in services, what they term 'consumption cities'. Similarly Fajgelbaum and Redding (2014) analyse the effects of Argentina's late 19th century opening to world trade—and the resulting agricultural export boom—on urbanisation and the pattern of economic activity. As here, they find that agricultural development promotes urbanisation through the demand for non-tradables. One key difference between this chapter and Fajgelbaum and Redding is that where they infer economic changes from changes in the urban population and trade flows combined with the structure of the model, I am able to directly observe measures of the composition of urban output. A second key difference is that while Fajgelbaum and Redding, characterise late 19th century Argentina as having free movement of labour, the same cannot be said of China which, given barriers to cross-national migration, makes the present results of particular relevance for understanding the effect of national improvements in agricultural technology.

This chapter also contributes to a growing literature on the causes, consequences, and nature of Chines urbanisation. However, while

previous papers have focussed on the role of infrastructure (Baum-Snow et al., 2012), migration restrictions (Au and Henderson, 2006a,b) and political favouritism (Chen and Henderson, 2015), this chapter focusses on China's rapid increase in agricultural productivity and it's causal effect on urbanisation through the forces of structural change. This chapter complements the more descriptive analyses of Deng et al. (2008, 2010), which find that GDP growth, and to a lesser extent its composition, were key correlates with the expansion of China's urban land area between 1987 and 2000.

Finally, this chapter is also related to the vast literature on the role of agriculture in facilitating structural change including, but not limited to, Echevarria (1997), Kongsamut et al. (2001), Gollin et al. (2007), Ngai and Pissarides (2007) and Bustos et al. (2014). The finding that agricultural development promotes the growth of the non-tradable sector at the expense of the tradable echoes the 'dutch-disease' effects suggested by Corden and Neary (1982) and Matsuyama (1992).

The rest of the chapter proceeds as follows. Section 2.2 provides additional background on urbanisation in China, the agricultural reforms and other relevant institutional details. Section 2.3 provides a simple theoretical framework to guide the empirical analysis. Section 2.4, describes China's administrative divisions, how they relate to urban areas, and the construction of the data. Section 2.5 provides the empirics. Section 2.6 concludes.

2.2 Background

2.2.1 Rural reforms and growth

Rural reforms beginning in 1978 marked the start of the reform-era. The reforms improved effort incentives for farming by decommunalising agriculture and introducing the Household Responsibility System (effectively smallholder peasant farming), and by increasing the price rural households faced for their produce. In addition to this, they

effectively liberalised the planting of cash crops by relaxing a policy of rural self sufficiency, substantially reducing quotas for grain deliveries to the central government as a share of the harvest, and by weakening the link between the political success of rural party cadres and local grain production.[6]

Agricultural output surged in response to the reforms. Having barely kept pace with population growth over the 25 years preceding the reforms, agricultural output increased 6.9% per year between 1978 and 1984. Lin (1992) suggests that decommunalisation alone increased agricultural output by around 20% between 1978-84 while Chapter 1 estimated that liberalising the planting cash crops increased output by up to 14% between 1978-85. Although these gains are not directly additive, it is clear that the reforms resulted in substantial increases in agricultural productivity.

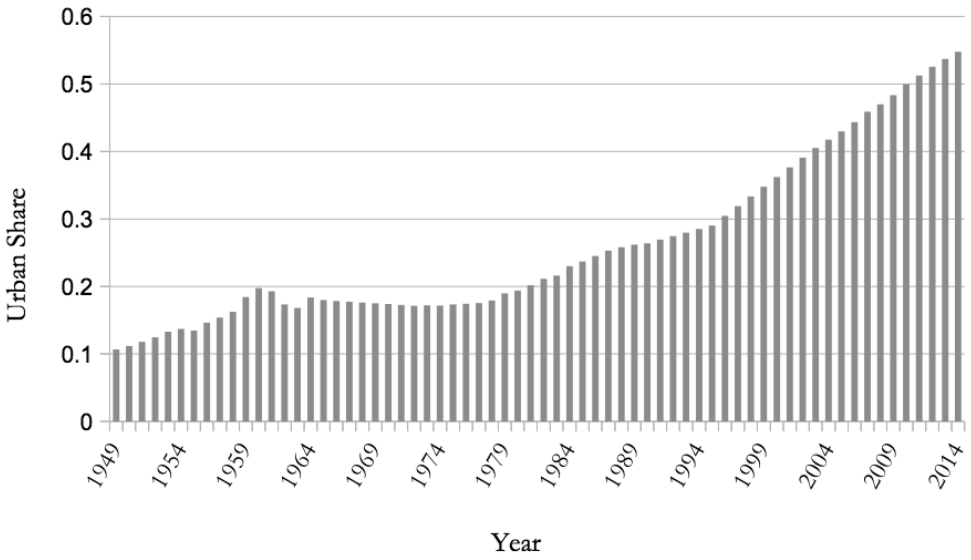
2.2.2 Urbanisation

In 1978, the start of the reform era, China was overwhelmingly rural, and the urban share of population had barely increased since the 1950's. More than more than 80% of China's population lived in the countryside. Since then, China has steadily urbanised. Figure 2.1 plots the urban share of population since 1949 based on the official categorisation. There are three distinct periods. Prior to 1978, the urban share of population was flat. Then, as the reform era dawned, it steadily increased from around 18% of the population to around 30% in the mid 1990's. From the mid 1990's migration restriction eased, growth switched from the countryside to the cities, and by 2014, 54% of the population was classified as urban.[7] To put the post-reform increase in urbanisation into context, the equivalent change in the US took around 80 years (1860-1940).

[6]See Chapter 1 for a somewhat extended description of China's pre-reform agricultural institutions and the reforms themselves. For a much richer view see Lardy (1983), Perkins (1988), Sicular (1988), Oi (1991), Lin (1992) and Huang (1998).

[7]Given the way Chinese figures are calculated, these later figures likely understate the true levels of urbanisation.

Figure 2.1: Urban Share of China's Population



Source: Authors calculations based on NBS data obtained from the University of Michigan's China Data Center.

Despite this rapid urbanisation, China is still relatively rural for its level of development (Taylor et al., 2003; Au and Henderson, 2006a). The most obvious culprit are the migration restrictions imposed by the *hukou* system, which are discussed below. However, because early economic reforms favoured agriculture and rural industry, it is possible that rapid growth in rural incomes constrained the pace of urbanisation. This, as well as the relaxation of migration restrictions, would be consistent with the apparent increase in the pace of urbanisation in the mid 1990's. In fact, this chapter will show that these early rural-biased reforms *increased* the pace of urbanisation during the 1980's and 90's by increasing the demand for urban non-tradables.

2.2.3 Migration restrictions

As mentioned, migration restrictions provide one explanation for the relatively low levels of urbanisation in China. Because, China's planners had prioritised urban development, and favoured urban areas with subsidised food and generous public services, large gaps between rural and urban living standards emerged. To prevent large flows of migrants to cities, and the political instability that a substantial population of urban poor could entail, China has tied access to land and public services to place of official residence through the *hukou* system.

The *hukou* provided each Chinese citizen with a place of registration and a classification as either 'agricultural' or 'non-agricultural'.[8] Access to public services such as health care and education in cities, and land in the countryside, is tied to ones official place of residence, as defined by the *hukou*. This imposed a substantial additional cost to migration, particularly over long distances, and particularly before the end of rationing in 1994.

Perhaps because of this levels of migration were low. In the 1% sample of the 1990 population census, only 3.3% of the population had moved county in the last five year. In the US, the comparable figure is 25%, while in India, a place often cited for it's low labour mobility, 2.7% of the population move district *each year*.[9] (Indian districts are also significantly larger than Chinese counties.) Evidence from a retrospective survey conducted by De Brauw et al. (2002) find similarly low levels of migration. Only 4% of the rural labour force were involved in migrant work in 1981, this increased to a little below 6% by 1990, 10% by 1995 and almost 16% in 2000. Because migration was very low up until the mid 1990's, my analysis will focus on the period up until 1995.

[8]See Cheng and Selden (1994) for a complete description of the origins of the *hukou* system and Chan and Zhang (1999) for a discussion of its reform in the 1990's.

[9]Figures from the US from 1980 and 1985 Current Population Survey available through IPUMS. More recent rounds of the CPS do not separate moves across county lines from moves within counties and are thus not comparable. Figures from India from the 64th round of the National Sample Survey (2007).

Even when migration across county lines did occur, it was often within prefecture (Chan, 2001; Baum-Snow et al., 2012). Low levels of migration, combined with migration being predominantly a within prefecture phenomenon, mean that when we see cities growing, most of their migrants will have originated in the nearby countryside. This is particularly true before the late 1990's. The benefit of this is that if we see a city growing, or the urban part of a prefecture growing, we can be reasonably sure that this represents a net increase in urbanisation rather than a diversion of urbanisation that otherwise would have happened elsewhere. Given my empirical analysis will exploit a difference-in-differences strategy, this is helpful for the interpretation of the results.

2.3 Conceptual Framework

To frame the empirical analysis I present a simple model of urbanisation and structural transformation which is a slight variant on that of Gollin et al. (2013).[10] The unit of analysis is the prefecture. Prefectures have a three sector economy comprising a rural (tradable) agricultural sector, and two urban sectors, one tradable (incorporating manufacturing and tradable services), and one non-tradable (incorporating locally consumed services such as entertainment, retail and government, construction, and any non-traded manufactures). Consumers have non-homothetic preferences and income elasticities of urban sector outputs greater than 1. Labour is assumed to be immobile reflecting the high cost and low rates of migration in China before the mid 1990's, described in section 2.2.3. The model will outline the likely consequences of a positive shock to rural productivity on urbanisation (i.e. the share of the population in the two urban sectors) and the composition of urban output.

[10]Gollin et al. include an exogenous source of 'manna from heaven' income (as a proxy for resource rents such as oil revenues) and consider the comparative statics with respect to that. Here, the shock is to agricultural sector productivity, and the manna from heaven resource is ignored.

Consumption

The prefecture is populated by a representative consumer with Stone-Geary type log-linear preferences over the consumption of agricultural goods c_a, tradables c_t and non-tradables c_n.

$$V = \beta_a \ln(c_a - \tilde{c}_a) + \beta_t \ln(c_t) + \beta_n \ln(c_n) \tag{2.1}$$

where $0 < \beta_j < 1$ is the weight in consumption of good j, and $\sum \beta_j = 1$. The subsistence requirement for agricultural $\tilde{c}_a$, ensures that the income elasticity of non-food goods is greater than 1.

The consumer maximises (2.1) subject to budget constraint

$$p_j c_j + p_j c_j + p_j c_j \leq I \tag{2.2}$$

which, as is standard, results in the consumer satisfying her subsistence requirement and spending share β_j of her residual income $(I - p_a \tilde{c}_a)$ on good j. Thus her uncompensated demands are

$$\begin{aligned} c_a p_a &= \beta_a (I - p_a \tilde{c}_a) + p_a \tilde{c}_a \\ c_t p_t &= \beta_t (I - p_a \tilde{c}_a) \\ c_n p_n &= \beta_n (I - p_a \tilde{c}_a) \end{aligned} \tag{2.3}$$

Production

Each prefecture has a profit maximising, price taking, representative firm in each sector. Labour, L_j, is the only factor of production. Production technologies are

$$Y_j = A_j L_j^{1-\alpha} \tag{2.4}$$

where $A_j > 0$ is the productivity level of sector j. (With productivities sufficiently high to ensure subsistence constraint does not bind.) The exponent $\alpha \in (0, 1)$, indicates each sector faces decreasing returns to

scale perhaps reflecting some fixed factor such as land, managerial talent, or political capital.

Reflecting the high cost and low rates of cross-prefectural migration in China, the total supply of labour is assumed to be inelastic and normalised to 1.[11] The labour market clearing condition is thus

$$1 = L_a + L_t + L_n \tag{2.5}$$

Labour markets are competitive within the prefecture so all sectors face the same wage. All wages and profits are remitted back to the representative consumer as I.

Prefectures are assumed to be small, so prices for tradable goods are set at the "whole of china" or world price (i.e. $p_a = \hat{p}_a$ and $p_t = \hat{p}_t$). As urban non-tradables are non-tradable $c_n = Y_n$. To close the model I impose balanced trade, such that $\sum_j p_j c_j = \sum_j p_j Y_j$.

Combining this with consumer demand for non-tradables (2.3), the production technology (2.4), and competition in the labour market, we can obtain the following expressions for labour demand

$$L_n = \beta_n \left(1 - \hat{p}_a \tilde{c}_a \frac{(1 - L_n)^\alpha}{\bar{A}}\right) \tag{2.6}$$

$$L_t = (1 - L_n) \left(\frac{\hat{p}_t A_t}{\bar{A}}\right)^{1/\alpha} \tag{2.7}$$

$$L_a = (1 - L_n) \left(\frac{\hat{p}_a A_a}{\bar{A}}\right)^{1/\alpha} \tag{2.8}$$

where $\bar{A} = [(p_a A_a)^{1/\alpha} + (p_t A_t)^{1/\alpha}]^\alpha$ is the composite productivity of the tradable sector. Defining the urbanisation rate as $U = L_t + L_n$ and applying Implicit Function Theorem to (2.6) and 2.7), we find that the effect of improvements of agricultural productivity on urbanisation is ambiguous and constitutes the net of two effects. The first is that higher agricultural productivity increases the returns to agriculture relative to

[11] That this assumption more or less holds will be verified in the empirical section of the chapter.

other activities (holding goods prices unchanged). The second effect is that higher agricultural productivity induces movement along the Engel curve and increases the relative price of non-traded goods and thus increases the share of labour in the non-agricultural sector.[12] The effect on the urban share of output is similarly ambiguous.

While there is ambiguity about the effect of increasing agricultural productivity on urbanisation writ large, there is no such ambiguity about the composition of urban output. The share of both urban labour and output in the non-traded sector increase at the expense of the traded sector.

The simple model presented here suggests two types of outcomes of interest. First, the effect of improvements of agricultural productivity on the rate of urbanisation. And second, the effect on the composition of urban output. These are the outcomes I will be exploring in the data.

2.4 Data

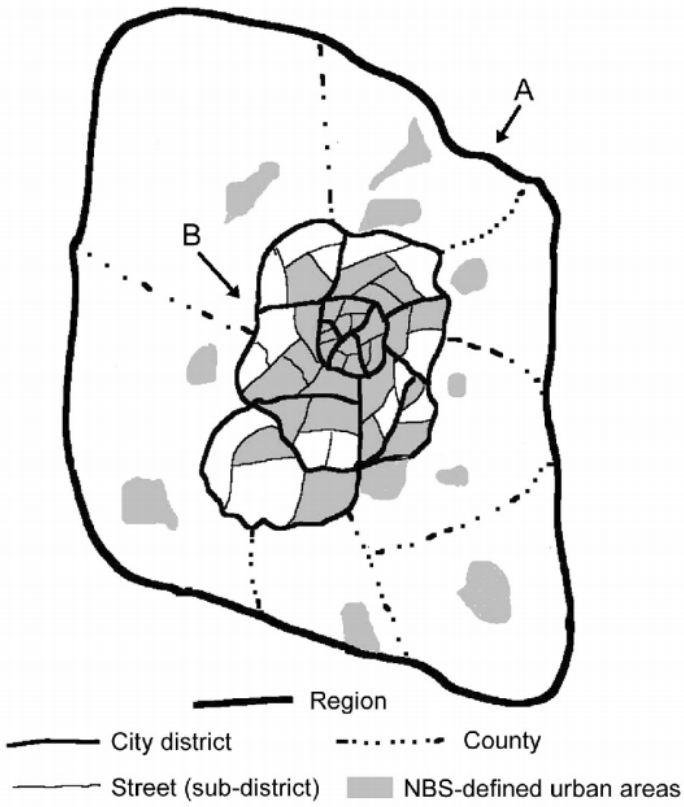
2.4.1 Cities in China

China's overlapping system of 'city' definitions is complicated. Much of this confusion stems from the fact that cities are both administrative regions and built up areas. The largest cities in China have province level administrative powers and govern the municipalities of Beijing, Tianjin, Shanghai and Chongqing which include the city proper plus some of the surrounding area. Other provinces in China are divided into prefectures (or equivalent) which are further subdivided into county level administrative units. Confusingly, prefectures are often also called known as cities despite encompassing almost all the land in China.

Figure 2.2 (from Chan, 2007) provides a schematic of a typical prefecture level administrative division. The prefecture is subdivided into

[12] To see this note that the share of labour in the non-agricultural sector increases if $(1 - L_n)^{1-\alpha}\bar{A} > \alpha\beta_n\hat{p}_a\tilde{c}_a$ which will always be the case as the left hand side is the joint output of the tradable sectors and we have assumed the subsistence constraint does not bind and that $0 < \alpha,\ \beta_n < 1$.

Figure 2.2: Conceptual diagram of the Administrative Structure of a Typical Chinese Prefecture



Source: Chan (2007, p. 387). Note that, this diagram is typical of Eastern (Han) China, where most prefectures have a central administrative city consisting of a number of county level districts. In Western China, the 'central city' is usually a standard county, albeit the one containing the administrative capital.

a number of county level administrative areas of three main types. The city districts (*qu*) form a central urban area (*shixiaqu*)—the area indicated by B in the figure. The rest of the prefecture is usually formed of counties *xian* and county level cities *shi*. Both the central urban area and the surrounding counties will include built up land and farmland, but the central urban area is usually the main urban area in the prefecture.

From the above, it should be clear that prefectures (city level administrative divisions) are not an appropriate urban area. Similar to Baum-Snow et al. (2012), I instead use the prefectures administrative district as a proxy for urban areas. For most prefectures in my data, these are the central urban areas described above, however, for a subset, mostly in Western China, these are regular counties that contain the administrative capital. (It is in using these Western administrative areas that this chapter departs from Baum-Snow et al..) As we shall see below, this latter type are geographically larger, and less economically distinct than central cities proper. Also as in Baum-Snow et al., I define the remainder of the prefecture as the hinterland. Thus, each prefecture has precisely one central administrative area, and up to one hinterland.

One complication is that administrative boundaries in China are not immutable. While the NBS have ensured the economic data I use refers to a consistent area, the areas themselves may be endogenous. For instance, a successful central administrative area may absorb surrounding rural areas. Alternatively, the most successful rural areas may themselves be promoted to urban status. In either case, central administrative areas could be a selected sample of fast growing areas.

To circumvent the problem of endogenous boundaries, I base my set of central cities on the prefectural administrative district as defined in the 1964 census. I manually compared the 1964 boundaries to the 1999 boundaries to identify the present day county level administrative division(s) that make up the 1964 central city. In the cases where a subset of the 1999 boundaries does not closely match the 1964 boundaries, the

prefecture is omitted from the analysis.[13] (Around 1/3 of prefectures in my provinces of interest.)

2.4.2 Economic data

The primary source of data on economic aggregates are the set of Anniversary Yearbooks published to mark the 50th and 60th anniversaries (1999 and 2009) of the People's Republic of China (PRC). These yearbooks were produced by the provinces and contain compendiums of local economic statistics. A subset of these yearbooks contain information on county level economic outcome both before and after the reforms. It is this subset from which my data is drawn. Combining the counties that make up the hinterland, I can produce consistent data for 47 central city hinterlands over a 30 year period. These make up the majority of cities in Gansu, Guizhou, Jiangsu, Hebei, Jiangxi, Xinjiang and Zhejiang.[14] Figure 2.4 indicates the central administrative areas in the data (shaded in dark grey), and their surrounding hinterlands (shaded with their suitability for cash crops).

Each province reports data on a separate set of years. I focus on the period for which migration was very low (up until the mid 1990's) as substantial flows of internal migrants would complicate the interpretation of the results. For reasons of balance, I focus the analysis on the set of years with maximal data overlap: 1965, 1970, 1978, 1985, 1990 and 1995. Even within the set of years proscribed by the provinces, there are occasional instances of missing or indecipherable data at the county level. A hinterland-year observation for say, population, is the total population of all the hinterlands constituent counties. To enable the calculation of hinterland aggregates in the presence of missing county observations, I interpolate a small number of missing observations on a geometric basis

[13]Note that because the 1964 boundaries are mapped less accurately than the 1999 boundaries, I am not able to ensure the matches are perfect.

[14]Other provinces lack the required data, usually because there anniversary yearbooks only report prefectural data, or data from 1978 onwards.

(provided that the county has both prior and subsequent non-missing observations).

Data Quality

Before proceeding, it is worth noting that, due to the way the data is collected, reported and processed, the data is more suitable for some purposes than others. For many provinces, data on the output of the central administrative area of a prefecture is not directly available for the period of interest. For the set of provinces I focus on, data is however available for both the prefecture as a whole, and the counties that make up the prefectures hinterland. In principle then, the population of the central administrative area can be inferred by deducting the sum of hinterland population from the prefectural total. (And the values other aggregate variables can be calculated analogously.) I.e.

$$CencityPop_i = PrefecturePop_i - \sum_{j \in i} CountyPop_j$$

Unfortunately, county and prefectural statistics are not always consistent, even within the same publication. It is not clear why this is the case at the prefectural level, but China's provincial and national statistics suffer from the same problem, partly because they are generated through different reporting systems, and partly because subregions inflate their own production data due to career concerns (Holz, 2014). As a consequence, for both provincial-national and county-prefectural data, the sum of the subregion output (counties and urban areas for prefectures) is often greater than that reported for the whole. Thus, imputing the output of the central city by deducting the county level values will tend to result in an underestimate of the true levels of output. This can be most vividly seen in the data for primary GDP and Gross Agricultural Output where, on occasion, imputed values can be negative. This is likely to be less of an issue for variables like population, than it is output, because there are fewer political incentives for over-reporting.

As a consequence of this misreporting, the economic data are not suited to decomposing the output of cities vis-á-vis their hinterlands, but this does not mean the data has no empirical value. The framework in section 2.3, suggested that one outcome of interest would be the share of output produces in urban areas. In the data, the analogue of this is the share of output of a prefecture produced in it's central city. The expression for the observed share is

$$\hat{S} = \frac{Y - Y_H(1+\alpha)}{Y} = 1 - \frac{Y_H}{Y}(1+\alpha)$$

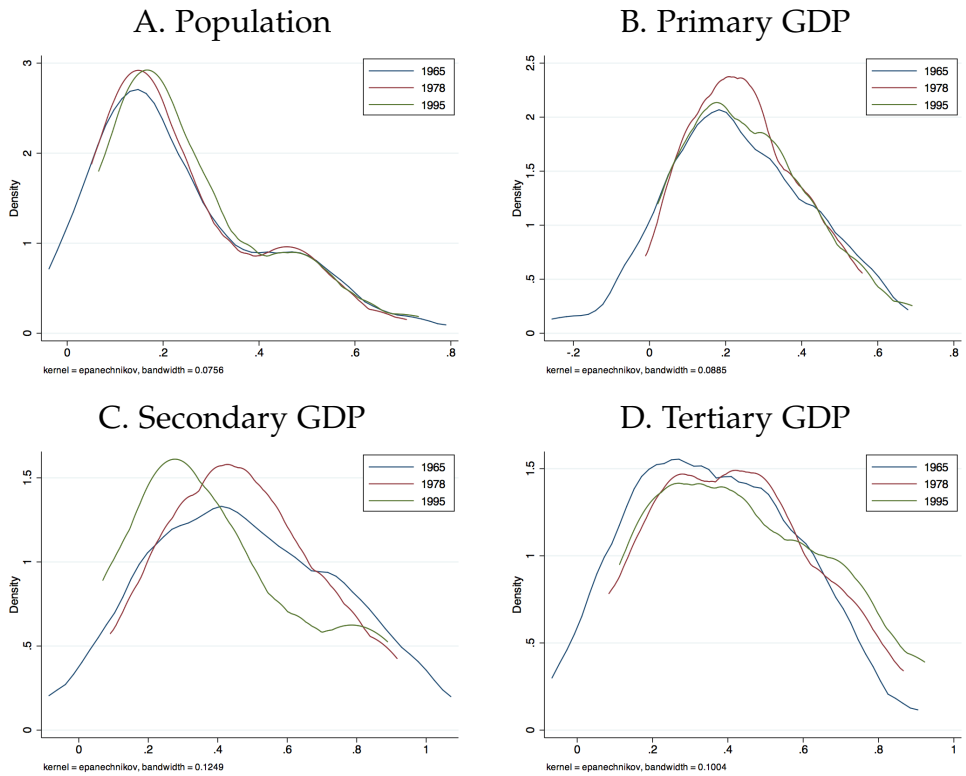
where α is the (unobserved and unknown) degree of bias, and Y_H and Y are true hinterland and prefectural GDPs. Clearly, in the cross section, the observed shares of output in the hinterland are downward biased to an unknown extent.[15] Similarly, a change in $\hat{S}$ over time could be due to change in the degree of bias in reporting α, or true changes in the composition in output. Thus the data is of limited value for making cross sectional comparisons, and pure time series changes must also be treated with caution. Despite this, in a difference-in-difference framework, the sign of the coefficient is unbiased provided changes in α are uncorrelated with changes in the variable of interest. (The absolute values of coefficients, and accompanying standard errors, will nevertheless be biased upwards.)

A look at the data

With these caveats in mind, it may be informative to look at the distribution of shares of population and output in 'urban' areas over time and see how the changes in distribution compare to known trends. Figure 2.3 contains these plots for urban areas where consistent data is available for 1965, 1978 and 1995. The share of population (2.3A) in urban areas increases modestly over time, particularly between 1978 and 1995,

[15]Note also, that the expression for the absolute value of bias is $\hat{S} - S = \alpha\frac{Y_H}{Y}$, the bias is larger the more important the hinterland share of output.

Figure 2.3: Shares of Variables in Central Administrative Areas



Notes: Kernel density plots of shares of prefectural population or output in central administrative areas. Data for 47 prefectures with constant boundaries and their surrounding hinterlands in Gansu, Guizhou, Hebei, Jiangsu, Jiangxi, Xinjiang, Zhejiang. Plots for 1965, 1978 and 1995.

consistent with the observed aggregate increase in urbanisation and the restrictions on migration.

The distribution of shares of Primary GDP (2.3B) do not change dramatically, as one might expect given fixed land endowments. However, that the distribution of Primary shares extends into negative territory in 1965, provides a stark illustration of the over-reporting in the data. The distribution of Secondary GDP (2.3C) is fairly similar in 1965 and 1978, but the share of Secondary output in urban areas declines dramatically by 1995. This is consistent with the Township and Village enterprise phenomenon that provided explosive growth in industrial output in the

countryside in the 1980's and early 1990's. Finally, the share of services captured by urban areas appears to increase somewhat over time. Given the underlying data, and limited geographic coverage, we should be careful not to place to much weight on these patterns, but they are reassuringly consistent with what is already known about China's general economic trends.

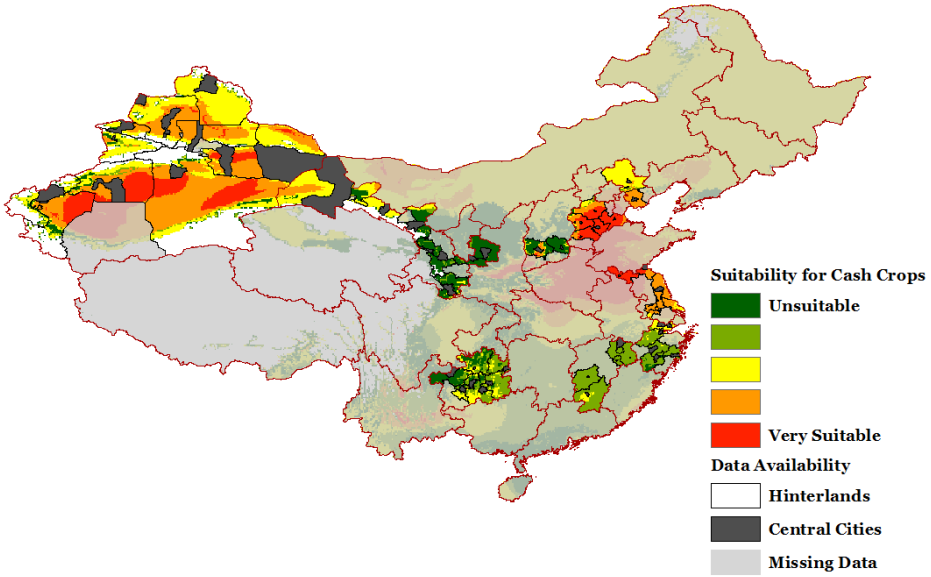
Eastern vs. Western China

In the West of China (Gansu and Xinjiang in my data), prefectures are organised differently than elsewhere. The administrative district tends to be a county containing the largest city, rather than something closer to a metropolitan area (and immediate surrounds). Indeed we can see in figure 2.4, that in Eastern, Central and Southern China the central administrative districts are small relative to their surrounding hinterlands, while in the West, and in particular in Xinjiang, the central administrative districts are large regions.

A similar pattern emerges when comparing the composition of output (table 2.1). Dividing the parts of China in my data into three regions: Eastern (Hebei, Jiangsu[16] and Zhejiang), Central (Guizhou and Jiangxi) and Western (Gansu and Xinjiang), we can see that the 1978 economic composition of Eastern and central cities and hinterlands are quite similar, but Western ones are quite different. Western cities and hinterlands are more agricultural and less industrial than their Eastern and Central counterparts. We can also see that while central areas are substantially more industrial and less agricultural than their hinterlands across China, they are much more alike in western China—as one might expect given their quite different geography.

[16] Although Jiangsu is considered part of the Eastern region the data do not contain GDP disaggregated into it's constituent parts and so it does not feature in this table.

Figure 2.4: Data Availability



Notes: Indicates prefectures and their central cities/administrative areas that have available data for both the central city and hinterland. The map highlights the difference between administrative regions (central cities) in Western China and elsewhere. In Western China administrative districts are counties that happen to hold the administrative capital, whereas elsewhere they tend to be geographically small metropolitan areas.

Table 2.1: Central Areas Versus Hinterlands in the Regions of China (1978)

	Eastern (E)	Central (C)	Western (W)	$E - C$ (T1)	$W - (E + C)/2$ (T2)
A. Central Cities					
(A1) Primary GDP Share	0.20	0.25	0.41	-0.054	0.19*
	(0.23)	(0.23)	(0.20)		
(A2) Secondary GDP Share	0.56	0.48	0.31	0.082	-0.22***
	(0.21)	(0.24)	(0.15)		
(A3) Tertiary GDP Share	0.24	0.28	0.28	-0.047	0.02
	(0.09)	(0.13)	(0.10)		
B. Hinterlands					
(B1) Primary GDP Share	0.52	0.58	0.58	-0.066	0.03
	(0.06)	(0.12)	(0.10)		
(B2) Secondary GDP Share	0.30	0.26	0.19	0.038	-0.085**
	(0.08)	(0.13)	(0.08		
(B3) Tertiary GDP Share	0.19	0.15	0.22	0.036	0.054***
	(0.03)	(0.03)	(0.05)		
C. City Share minus Hinterland Share					
(A1-B1) Primary	-0.32***	-0.33***	-0.17***		
(A2-B2) Secondary	0.27***	0.23**	0.12**		
(A3-B3) Tertiary	0.05	0.13***	0.06		

Sample standard errors are included in parenthesis. Panels A and B contain summary statistics for the composition of output in selected central cities and hinterlands in China's Eastern (Zhejiang and Hebei), Central (Jiangxi and Guizhou) and Western (Gansu and Xinjiang) provinces. Column T1 compares Eastern and Central Areas. T2 compares Eastern and Central Areas to Western Areas. Bonferroni corrected (6 tests) significant differences are indicated in the normal way (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). Eastern and Central areas are quite similar to each other, but quite different from Western areas. Panel C compares central cities to hinterlands within the same region (significance Bonferroni corrected for 3 tests). In the data, central areas are less agricultural and more industrial than their corresponding hinterlands, but the difference is less pronounced in Western China.

2.4.3 Suitability data

The empirical strategy will exploit plausibly exogenous variation in agricultural productivity growth provided by China's agricultural reforms. As decribed in 2.2.1, parts of China endowed with land suited to growing cash crops benefitted more from the reforms as the planting of these crops was liberalised. I identify the suitability of prefectures and their hinterlands to cash crops using the Food and Agriculture Organisation's GAEZ database of theoretical soil productivities and information on the pre-reform government set prices of these crops from Sicular (1988).

The measure of suitability is constructed as in chapter 1. I provide a brief description of how the data is constructed here, but for full details the interested reader is referred back to that chapter. Suitability at location ι is defined as the as the ratio of the value of output in cash crops relative to that in grain

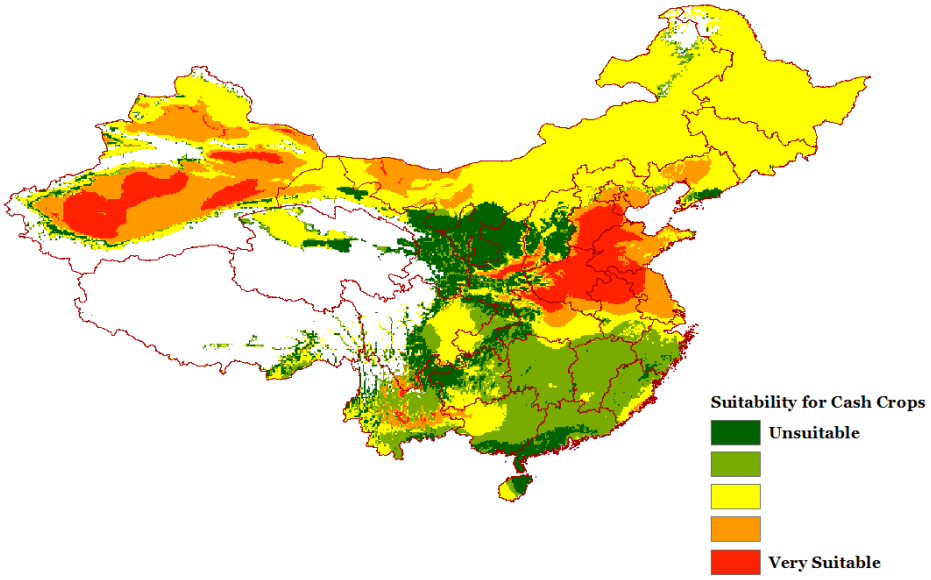
$$SCC_{\iota} = \frac{\max\{\Psi_{c\iota} p_c\}_{c \in \mathbb{C}}}{\max\{\Psi_{c\iota} p_c\}_{c \in \mathbb{G}}} \tag{2.9}$$

where p_c is the price of crop c, Ψ_c yield, and $\mathbb{C}$ and $\mathbb{G}$ are the set of cash crops and grains respectively. Because the measure is relative, it captures the proportional gains from switching to cash crops.

The GAEZ data provides a measure of Ψ_c for a large number of crops based on a theoretical agronomic model. The model translates plausibly exogenous inputs, such as soil type, climate, elevation and slope, into a theoretical yield at a high spatial resolution (6.5km square in Beijing).[17] I use pre-reform Above-Quota prices from Sicular (1988), as these were fixed across China for most crops and are plausibly exogenous to the changes in agricultural production induced by the reforms. The set of crops are the major crops of China for which both price and productivity

[17] Within economics, the use of the GAEZ data was pioneered by Nunn and Qian (2011), and the data has been used subsequently by numerous authors including Costinot and Donaldson (2014); Bustos et al. (2014).

Figure 2.5: Suitability for Cash Crops



Notes: Suitability for cash crops is the ratio of the highest value cash crop to the highest value grain based on GAEZ productivities and pre-reform above-quota prices. Underlying variable is continuous and values have been grouped into 5 Jenks categories for readability.

data is available: cotton, peanut and rapeseed (the cash crops), and wheat, rice, maize and soy (the grains).[18]

Figure 2.5 depicts how suitability for cash crops varies across China. Significant variation exists nationally and regionally. For the empirical analysis, I aggregate the gridcell level data to the prefectural level by taking a simple average of the suitability within that prefecture. I treat hinterlands and central cities as integrated systems and so apply the same suitability to both.

[18]In the Chinese system of quotas soybeans were classified as a grain. Excluding soy, or classifying it as a cash crop, does not change the results.

2.5 Empirics

The simple model provided in section 2.3 suggested that improvements in agricultural productivity have the following consequences for urbanisation, and the composition of urban output: (1) the effect on the urbanisation rates is theoretically ambiguous; (2) that the share of output in the city should decrease relative to the share of the population; and (3) that the composition of output in urban areas should shift towards non-tradables.

The basic empirical strategy employed is difference-in-differences with a continuous treatment. The empirical results are obtained based on variants of the following specification

$$Y_{it} = \alpha_i + \gamma_t + \beta(SCC_i \times Post78_t) + \epsilon_{it} \tag{2.10}$$

where α_i is a prefectural fixed effect, γ_t is a time fixed effect (or in more demanding specifications, a region-by-time fixed effect) and β_1 is my coefficient of interest capturing the differential effects of agricultural reforms.

As described above, central administrative areas are less urbanised and less distinct from their hinterlands in Western China due to systematic differences in administrative organisation. Because of this, I also report the results of specifications where I allow the effects to differ by region and include an interaction with a dummy for 'west'

$$\begin{aligned} Y_{it} = \alpha_i + \gamma_t + \beta_1(SCC_i \times Post78_t) + \beta_2(SCC_i \times Post78_t \times West) \\ + \beta_3(Post78_t \times West) + \epsilon_{it} \end{aligned} \tag{2.11}$$

Because central administrative areas are economically similar to their surroundings in the West, while at the same time being geographically distant, we would not expect higher incomes in the countryside to have as strong an effect on the composition of central administrative area output. We can think of the coefficient on the triple difference as a quasi-placebo test for the alternative hypothesis that higher rural incomes affected

Table 2.2: Prefectural Population and GDP

	Ln GDP		*Ln Primary GDP*		*Ln Population*	
	(1)	(2)	(3)	(4)	(5)	(6)
Suitability for Cash Crops × Post 1978	0.145*** (0.042)	0.095* (0.055)	0.246*** (0.081)	0.235*** (0.085)	0.010 (0.022)	0.052* (0.029)
Observations	231	231	201	201	232	232
Prefectures	49	49	43	43	48	48
Central City/Hinterland FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes		Yes		Yes	
Region-Time FE		Yes		Yes		Yes

Robust standard errors clustered at the prefecture level (*** p<0.01, ** p<0.05, * p<0.1). Data from central cities with constant boundaries and their surrounding hinterlands in Gansu, Guizhou, Hebei, Jiangsu, Jiangxi, Xinjiang, Zhejiang, for the years 1970, 1978, 1985, 1990 and 1995. Post refers to years after 1978.

central region output by empowering prefectural administrations, instead of through the forces of structural changed described in the conceptual framework. (Where we would expect β_2 to be of the opposite sign to β_1 and statistically significant, if the results are driven by the economic forces linking urban areas to the countryside described in the model.)

2.5.1 Effects on prefectural population and output

Chapter 1 showed that, for a larger set of mostly rural counties, suitability for cash crops was associated with higher growth in agricultural and non-agricultural output, investment, and savings. Because the sample and unit of observations are slightly different, it is worth beginning by verifying that suitability for cash crops is associated with higher output growth for the prefectures in this sample.

Table 2.2 provides these results. Depending on specification, a one standard deviation increase in suitability is associated with either 16%, with time fixed effects, or 10%, with region-time fixed effects, increases in post-reform output (column 1 and 2). These estimates are significant at the 1% and 10% levels respectively.

The increases in output are concentrated in primary GDP (columns 3 and 4) which reflects that this is a shock to agricultural productivity

shock.[19] The estimates of the effect on primary GDP are significant at the 1% level.

Consistent with China's substantial geographic barriers to labour mobility, the effect on population is small (columns 5 and 6). A one standard deviation increase in suitability is associated with a 1% or 5% increase in population, with the latter estimate being significant at the 10% level. At least some of the slight increase in population observed is likely due to the increase in fertility observed in these areas (see Chapter 3).

Chapter 1 contained a large number of robustness tests for quite similar specification including allowing for additional controls different specifications, and alternative calculations of suitability. Chapter 1 also showed that, prior to the reforms, areas more or less suited to cash crops were following parallel trends, and that they are quite similar to each other on observable characteristics. In the interests of brevity, I do not provide similar results here.

2.5.2 Effects on urbanisation

So did improvements in agricultural productivity promote urbanisation? To explore this I calculate the share of a prefectures population that lives in the administrative district. Because the urban population tends to be concentrated in the administrative district, this provides a good, if imperfect, proxy for prefectural urbanisation (Baum-Snow et al., 2012). As highlighted in section 2.3, this change is expected to be the net of two opposing forces—higher local incomes driving up the demand for non-tradable output, and higher agricultural productivity diverting labour from the tradable non-agricultural sector.

[19] Note that while Chapter 1, showed that there were substantial spillovers from the agricultural to non-agricultural sectors, the full spillovers were not observed until the mid 1990's, and the analysis continued until 2008. As the data here finishes in 1995, it is not thus not surprising that the observed increase in output is concentrated in the agricultural sector.

Table 2.3: Urban Share of Population

	(1)	(2)	(3)	(4)
Suitability for Cash Crops × Post 1978	0.004*	0.006**	0.003	0.007**
	(0.002)	(0.003)	(0.003)	(0.003)
Suitability for Cash Crops × Post 1978 × West		-0.008		-0.009
		(0.005)		(0.006)
Post 1978 × West		-0.011**		
		(0.005)		
Observations	220	220	220	220
Cities	47	47	47	47
Prefecture FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes		
Region-Time FE			Yes	Yes

Robust standard errors clustered at the prefecture level (*** p<0.01, ** p<0.05, * p<0.1). Data from central cities with constant boundaries and their surrounding hinterlands in Gansu, Guizhou, Hebei, Jiangsu, Jiangxi, Xinjiang, Zhejiang, for the years 1970, 1978, 1985, 1990 and 1995. Post refers to years after 1978. West is a Gansu/Xinjiang dummy to allow for the fact that 'central cities' are quite similar to their hinterlands in Western China. The outcome variable is the share of the population of the prefecture in the prefectures 'central city'.

Table 2.3, provides the results. Across the whole of China, increases in agricultural productivity are positively associated with urbanisation (columns 1 and 3). Although the point estimate is almost unchanged, the estimated coefficient is not statistically significant in the presence of region-time fixed effects indicating that they may be soaking up some of the variation in our variable of interest.

When the effect on urbanisation is estimated separately for Western and 'core' China, we see that the effect is solely observable in core China: here a one standard deviation increase in suitability is associated with a 0.7 percentage point increase in the urban share of the population (column 2). This increase is significant at the 5% level. Almost identical results are obtained when allowing for more demanding region-by-time fixed effects (column 4).

The stark differences in the estimated effects observed in Western and 'core' China is reassuring as, in Western China, administrative districts are much less urban, much more like their hinterlands economically, and yet—by virtue of the large size of their prefectures— much more distant from their hinterlands geographically. This difference suggests that the changes observed are being driven by the forces of urbanisation and structural transformation forces described in section 2.3, rather than some other characteristic of central cities such as their ability to expropriate surplus from the countryside.

Urban share of output

As with any difference-in-difference strategy, a primary concern is that the treatment, in this case suitability for cash crops, is correlated with other changes that might affect our outcome of interest. Of particular concern in this case, is the possibility that agricultural productivity shocks were correlated with shocks to urban productivity. If this were so, the urban/rural wage gap could have increased in these areas providing an alternative explanation for the increase in urbansiation. While I lack the data to conclusively test this, I can explore whether these prefectures increased the urban share of their output.

Table 2.4 provides the relevant results. Higher agricultural productivity is associated with a decline in the urban share of output, although the decline is not statistically significant in specifications including the more-demanding region-by-time fixed effects (the estimated coefficients are almost identical). These results are not indicative of substantial correlated shocks to urban output.

2.5.3 Effects on the composition of output

Consistent with the simple model of structural change presented in section 2.3, we have seen that higher agricultural productivity led to more urbanisation, yet a slight decline in the share of output produced in urban areas. In the model, changes of this type are expected to be accompanied

Table 2.4: Urban Share of Output

	(1)	(2)	(3)	(4)
Suitability for Cash Crops × Post 1978	-0.023**	-0.025*	-0.019	-0.020
	(0.010)	(0.013)	(0.011)	(0.014)
Suitability for Cash Crops × Post 1978 × West		0.007		0.002
		(0.022)		(0.023)
Post 1978 × West		0.023		
		(0.023)		
Observations	212	212	212	212
Cities	47	47	47	47
Prefecture FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes		
Region-Time FE			Yes	Yes

Robust standard errors clustered at the prefecture level (*** p<0.01, ** p<0.05, * p<0.1). Data from central cities with constant boundaries and their surrounding hinterlands in Gansu, Guizhou, Hebei, Jiangsu, Jiangxi, Xinjiang, Zhejiang, for the years 1970, 1978, 1985, 1990 and 1995. Post refers to years after 1978. West is a Gansu/Xinjiang dummy to allow for the fact that 'central cities' are quite similar to their hinterlands in Western China (see text for more details). The outcome variable is the share of the GDP of the prefecture in the prefectures 'central city'.

by a change in the structure of the urban economy. In particular, we would expect the tradable urban sector to contract while the non-traded sector expands. Although I do not observe tradable and non-tradable output, secondary and tertiary output provide reasonable proxies on the assumption that services are more tradable than industrial output.

Central administrative areas

Table 2.5 contains results relating increases in rural incomes to changes in the composition of the output of urban areas. In Panel A, we can see that in response to increasing agricultural productivity (and later industrial output), urban areas in core China specialise in non-tradable services. In Western China, where the central administrative areas are both economically fairly similar to their surrounding hinterlands and, by

virtue of their large size, geographically distant, there is no such apparent change in composition (Columns 2 and 4). This regional difference is also consistent with the different effects observed for urbanisation.

In panel B, we see that the increase in the share of services comes at the expense of the secondary sector (primarily manufacturing). As manufacturing declines more than services expand, higher agricultural productivity appears to have increased the share of the primary sector which, given that 'cities' also contain some rural land, suggests a change in the composition of tradable output in line with the shift in comparative advantage. Together these results are again consistent with the simple model of structural change and urbanisation provided.

Hinterlands

Similarly to areas of Western China, there is no evidence of substantial changes in the composition of output in response to higher agricultural productivity in the hinterlands. If anything the share of agriculture in output increase at the expense of manufacturing. But, consistent with the large spillovers from the agricultural to non-agricultural sectors demonstrated in Chapter 1, the increase in the share of output in the primary sector is quite modest. As in the central administrative areas, where the share of agricultural output increases, it appears to increase primarily at the extent of secondary output—which is dominated by manufacturing and hence fairly tradable.

Table 2.5: Composition of Central Administrative Areas Output

	(1)	(2)	(3)	(4)
A. Tertiary GDP				
Suitability for Cash	0.014	0.048***	0.008	0.059***
Crops × Post 1978	(0.016)	(0.018)	(0.016)	(0.019)
Suitability for Cash		-0.072***		-0.082***
Crops × Post 1978 × West		(0.024)		(0.026)
Post 1978 ×		-0.017		
West		(0.027)		
Observations	181	181	181	181
Cities	39	39	39	39
B. Secondary GDP				
Suitability for Cash	-0.034	-0.082***	-0.042*	-0.135***
Crops × Post 1978	(0.022)	(0.024)	(0.023)	(0.020)
Suitability for Cash		0.099***		0.152***
Crops × Post 1978 × West		(0.030)		(0.028)
Post 1978 ×		0.046		
West		(0.031)		
Observations	185	185	185	185
Cities	40	40	40	40
Prefecture FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes		
Region-Time FE			Yes	Yes

Robust standard errors clustered at the prefecture level (*** p<0.01, ** p<0.05, * p<0.1). Data from prefectures in Gansu, Guizhou, Hebei, Jiangsu, Jiangxi, Xinjiang, Zhejiang, for the years 1970, 1978, 1985, 1990 and 1995. SCC is my normalised measure of suitability for cash crops. The outcome variable is the share of Tertiary of Secondary GDP of the prefecture in the prefectures administrative district. West is a dummy indicating that a prefecture is in Gansu or Xinjiang.

Table 2.6: Composition of Hinterland Output

	(1)	(2)	(3)	(4)
A. Tertiary GDP				
Suitability for Cash	-0.009	-0.002	-0.009	-0.004
Crops × Post 1978	(0.007)	(0.004)	(0.009)	(0.005)
Suitability for Cash		-0.011		-0.009
Crops × Post 1978 × West		(0.015)		(0.015)
Post 1978 ×		-0.033**		
West		(0.013)		
Observations	191	191	191	191
Cities	42	42	42	42
B. Secondary GDP				
Suitability for Cash	-0.003	-0.006	-0.015	-0.040**
Crops × Post 1978	(0.011)	(0.016)	(0.012)	(0.019)
Suitability for Cash		0.009		0.043*
Crops × Post 1978 × West		(0.021)		(0.023)
Post 1978 ×		-0.016		
West		(0.021)		
Observations	195	195	195	195
Cities	43	43	43	43
Prefecture FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes		
Region-Time FE			Yes	Yes

Robust standard errors clustered at the prefecture level (*** p<0.01, ** p<0.05, * p<0.1). Data from prefectures in Gansu, Guizhou, Hebei, Jiangsu, Jiangxi, Xinjiang, Zhejiang, for the years 1970, 1978, 1985, 1990 and 1995. SCC is my normalised measure of suitability for cash crops. The outcome variable is the share of Tertiary or Secondary GDP of the prefecture in the prefectures hinterland. West is a dummy indicating that a prefecture is in Gansu or Xinjiang.

2.6 Conclusion

This chapter used a natural experiment provide by China's agricultural reforms to provide causal evidence on the effect of higher rural incomes on urbanisation. Parts of China which had faster post-reform growth in agricultural productivity had more rapid post-reform urbanisation. Cities in these areas also increasingly specialised in the production of services relative to cities elsewhere.

These findings are consistent with the predictions of a simple model where structural change is one of the key drivers of urbanisation. The chapter thus contributes to an emerging literature which highlighting that urbanisation and structural transformation are tightly bound together (Michaels et al., 2012; Jedwab, 2013; Gollin et al., 2013; Fajgelbaum and Redding, 2014). The results of this chapter also provide additional evidence on the importance of local income growth in the demand for urban produced consumption services.

Chapter 3

Family Size and the Demand for Sex Selection: Evidence From China

China, like many other countries, has many fewer women than expected given natural birth and death rates. As elsewhere, this imbalance has worsened significantly over the last 30 years, thanks, in large part, to a rise in sex selective abortion. The fall in fertility per woman that has taken place approximately contemporaneously is an oft mooted source of the demand for sex selection: fewer births make it harder to have the 'at least one son' many families desire. This chapter provides causal evidence on the link between fertility and sex selection in China. The One Child Policy (1CP) has reduced fertility in China by imposing economic, and sometimes non-economic sanctions, for breaching proscribed fertility levels. The economic sanctions have meant that, within a class of households, the 1CP constrained the fertility of poor households more than rich ones. I exploit plausibly exogenous variation in income growth at the county level provided by China's agricultural reforms in the early 1980's to overcome the endogeneity of income to fertility and son preferences. I show that higher incomes were indeed associated with higher fertility under the 1CP. I then show that this increase in fertility is subsequently associated with a

fall in sex selection. The timing of the changes in fertility and sex selection are informative: while fertility increased almost immediately after the reforms increased incomes, the relative decline in sex selection only emerged from the mid 1980's—roughly contemporaneous with the widespread availability of cheap sex detection technology. These results suggest that the dramatic decline in fertility in the 1970's China, as well as the smaller decline due to the One Child Policy in the 1980's, may have had an important role in fuelling the demand for sex selection in China.

3.1 Introduction

Many countries, particularly in South and East Asia, have shares of men in the population that far exceed those observed in Western Europe and North America. This surfeit of men implies a shortfall of women, the *missing women* of Sen (1990, 1992). Although these women are mostly missing from countries which are poorer than those in the west, development does not appear to resolve the imbalance. Rapid economic growth over the past 30 years in India, China, South Korea and Taiwan has been accompanied by increasingly biased sex ratios.

Several factors have been implicated in this trend. Parents in South and East Asian countries often have a preference for sons, which can lead to sex selective abortions and differential levels of care during childhood.[1] It is thus possible that the rapid economic and social changes in these countries may have strengthened preferences for sons.[2] Regardless of whether preferences changed, widespread availability of ultrasound technology from the early 1980's undoubtedly reduced the cost of acting on these preferences, and led to a boom in sex selective abortions (Chen et al., 2013; Lin et al., 2014). Finally, by reducing the probability of having a boy by chance, fertility transitions in these countries may have increased the number of parents having one by design (Park and Cho, 1995; Das Gupta and Mari Bhat, 1997; Das Gupta and Shuzhuo, 1999).

Although the role of ultrasound technology seems clear, untangling the impact of fertility transition from preference change and economic transformation has proven challenging. Jayachandran (2014) provides compelling evidence that lower hypothetical fertility increases the *desired* share of boys, but it is not obvious how desire translates into actions. Perhaps then, the most persuasive evidence in favour of the fertility transition hypothesis comes from two papers evaluating the

[1] In fact, as shown by Anderson and Ray (2010), women face excess mortality throughout the life cycle.

[2] One channel that economic outcomes have been shown to affect son preference is through changes in women's labour market prospects (Rosenzweig and Schultz, 1982; Qian, 2008).

consequences of the One Child Policy (Ebenstein, 2010; Bulte et al., 2011). These papers, which respectively exploit provincial variation in financial penalties and the differential enforcement faced by minorities, show that stricter enforcement is associated with lower fertility and greater gender imbalance. However, because of the strong regional component in the variation exploited by Ebenstein and the fundamental differences between the treatment and control group of Bulte et al., it is not clear whether these changes are driven by pre-existing differences in preferences interacting with the arrival of sex selective abortion, differential trends in preferences for total fertility and sons, or the fertility restrictions imposed by the One Child Policy (1CP).

This chapter also explores the link between fertility and sex selection in China. Since 1979, the 1CP has limited fertility by imposing sanctions on households which breach the proscribed family size. Because the sanctions are primarily economic, the relatively well off have often been willing and able to bear these sanctions (Scharping, 2013, pp. 142-143). From the early 1980's, the severity of the fines was set at the provincial level, so within a province, richer individuals may be less constrained in their fertility by the 1CP.[3] If this were the case then, other things equal, richer households would have more children in general and, under the fertility transition hypothesis, more girls in particular. However, incomes are normally endogenous to preferences for fertility and sons (Jayachandran, 2014) and access to sex selection technology, so it is not sufficient to simply compare the fertility choices of the rich and poor.

To overcome the endogeneity of income, this chapter exploits the plausibly exogenous variation in income growth provided by China's agricultural reforms (1978-84). Because the reforms liberalised the planting of cash crops, parts of China endowed with land suited to

[3]This is not to imply that fines were invariant within a province. Indeed, they were typically related to both household income (although very imperfectly in the countryside where measurement was highly problematic) and place of residence and the enthusiasm with which they were enforced could vary. Nevertheless, with decreasing marginal utility of income, even a perfectly proportional fine is less onerous for a rich household than a poor one.

growing cotton and oilseeds—the main cash crops in early 1980's China—had faster post reform growth (see chapter 1). Expanded freedom to grow cotton and oilseeds increased agricultural output by around 10% nationwide between 1978-85, but much more in counties endowed with land suited to their production. As suitability for cash crops was uncorrelated with incomes prior to the reforms, the additional growth in output provides a plausibly exogenous source of within-province variation in income levels, and hence the ability to afford the fines associated with a breach of the 1CP.

To test whether higher incomes did relax the constraints imposed by the 1CP, I impute the complete fertility histories of more than 700,000 married women born between 1945 and 1960 using the 1% sample of 1990 census. Using a difference-in-difference strategy, I show that women resident in counties of China endowed with land suited for growing cash crops—which had faster post reform income growth—had significantly higher fertility after the reforms than their counterparts residing in counties suited to grain. The results exploit only within province-variation and hence only variation within a given fine regime. I show that there were no differential trends in fertility prior to the reform, which supports the key parallel trends assumption. Furthermore, a placebo test comparing the effect on Han and non-Han populations indicates that only Han Chinese—whose fertility were much more constrained by the 1CP—increased their fertility in response to higher incomes. These results are consistent with higher incomes increasing households ability and willingness to pay the high costs of additional children imposed by the 1CP.[4] As a corollary, these results suggest that the fertility restrictions imposed by the 1CP did indeed reduce fertility.

[4]As labour utilisation was typically higher for cash crops than for grains (Taylor, 1988) is is also possible that growing cash crops increased the demand for children as a source of labour. However, because of the relatively high ratios of land to labour, and the large quantities of 'surplus' adult labour created by the reforms it is unlikely that households faced a major labour shortage. Consistent with this, Bowlus and Sicular (2003) document that, in the early 1990's, an additional child increases a households days spent in the field by just 25.

Next, I show that households in these areas of plausibly exogenous higher fertility also engaged in less sex selection.[5] Exploiting the fact that, for second born children, households only appear to engage in sex selection if the firstborn child is a girl (Figure 3.1; Yi et al., 1993; Ebenstein, 2007), I use a triple-difference strategy to investigate the effect of higher fertility on sex ratios. The differences are: (1) the timing of the reforms; (2) how beneficial the reforms were (suitability for cash crops); and (3) the gender of the older sibling. This formulation allows for pre-existing differences in son preference by county, county specific economic and environmental shocks to 'natural' (gender specific) birth and survival rates, and trends in sex selection over time (by province). As with fertility, there was no differential trend in sex selection prior to the reforms, whereas after the reforms, and accompanying the nationwide increase in sex selection, the level of sex selection declined in the same areas that had increases in fertility. These results suggest that the fertility declines induced by the 1CP increased sex selection in China, and more generally, that fertility declines across South and East Asia over the last thirty years are an important factor in the overall increase in the share of men in the population.

This chapter is most closely related to Almond et al. (2013), which also explores the affect of agricultural reform related increases in income on sex selection in second born children. However, despite these similarities the results are quite different. While I find higher incomes increased fertility and reduced sex selection (consistent with higher incomes alleviating the fertility constraints imposed by the 1CP), Almond et al. find that China's higher incomes *increased* sex selection. This difference is likely attributable to two factors. First, rather than exploit cross sectional variation in the beneficial effects of the reforms interacted with the general timing of the reforms, they exploit variation in the

[5]In fact, what I show is that the share of women in a given cohort that have survived until 1990 is higher in places relatively suited to cash crops after the reform than before the reform. However, as there is limited gender biased excess mortality for children in China (Anderson and Ray, 2010), these differences primarily reflect prenatal sex selection and excess mortality immediately following birth.

specific timing of the rollout of the reforms at the county level. As the rollout was completed almost entirely between 1982 and 1984, they ought only to be able to capture the very short run effects of higher incomes and the 1CP. Second, unlike the present chapter, they do not allow for differential trends in sex selection conditional on the gender of an older sibling. As sex selection was increasing substantially during and after the reforms for households which didn't already have a boy, it is possible that this omission biased their results towards finding that the reforms increased sex selection.[6]

This chapter is also closely related to Qian (2008), which uses the increased economic returns associated with tea and orchard crops in the wake of China's reforms to explore the consequences of the differential labour market performance of men and women on gender bias. She shows that female (male) biased income changes reduce (increase) son preference. This chapter asks a different question: it uses variation incomes provided by the reforms to show that the economic sanctions associated with the One Child Policy did constrain fertility. Then using this plausibly exogenous variation in fertility, it explores the link between fertility transition and sex selection which has often been argued to have been a major force in much of Asia's increasingly imbalanced sex ratio.

The remainder of the chapter proceeds as follows. Section 3.2 provides additional background to sex selection, fertility policy and agricultural reforms in China. Section 3.3 provides a simple conceptual framework for thinking about the interaction between income, fertility and sex selection in the presence of son preference. Section 3.4 provides the empirics, first establishing the link between suitability and incomes (Section 3.4.1), then exploring the link between incomes and fertility (Section 3.4.2), before

[6]Their most rigourous specification is $Boy^2_{ijt} = \alpha + \beta_2 Girl^1_{int} + \beta_3 Reform \times Girl^1_{ijt} + \gamma_{jt} + \epsilon_{ijt}$ where the unit of observation is the second born child, *Boy* is a dummy for if it is a boy, *Girl* a dummy for if it's older sibling was a girl and γ_{jt} and county-by-time fixed effect. (Almond et al., 2013, Equation 2, p.11). The citation provided is for the 2013 NBER working chapter version, which is likely to be stable and consistently available, however a version dated May 2014 employs the same specification.

finally evaluating the link between fertility and gender ratios (Section 3.4.3). Section 3.5 concludes.

3.2 Background

3.2.1 Fertility policy and fertility in the Peoples Republic of China (1949—)

This section provides an introduction to fertility policy and fertility in the Peoples Republic of China (PRC). It is based on the much more extensive treatments of the topic provided by Chang et al. (2005), White (2006) and Scharping (2013).

Early Years to 1978

In the early years of the PRC, little was done to control the population. Tentative steps were made to increase the availability of contraceptives, first in urban areas and then in the countryside. These initial efforts, expanded into campaigns encouraging later marriage and longer gaps between births. However, these early forays into population control were soon abandoned in the wake of the collapse in birth rates and chaos accompanying the disastrous Great Leap Forward (1959-61).

Fertility rebounded after the end of the Great Leap Forward. Birth control programs were quickly reinstated in cities, but little action was taken in the countryside. Total fertility fluctuated at around 6 births per woman for the rest of the sixties.[7] Concerns over high birth rates eventually led to fertility control policies being reintroduced to the countryside. Campaigns exhorting that 'one [child] is not too few, two, just right, three too many' and that births ought to be 'later, longer, and fewer' (where longer refers to gaps between births) were instrumental in the precipitous decline in fertility from more than 6 births per woman in the late 1960's to 2.7 in 1978.

[7] Total fertility is the expected lifetime fertility per woman.

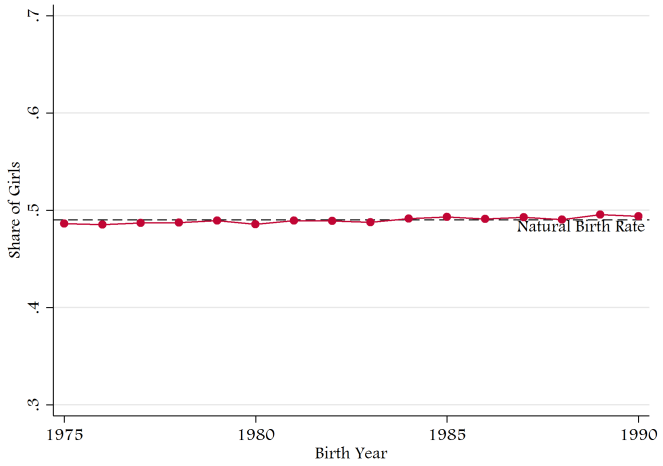
From 1979: The One Child Policy

The 'One Child Policy' was introduced beginning in 1979. In the early days, the degree to which it was enforced varied widely. Sanctions were sometimes draconian and, in some areas, included forced abortions, sterilisations and severe financial penalties. Propaganda campaigns encouraged sterilisation in households with more than two children. Passive resistance to the 1CP in the countryside was widespread.

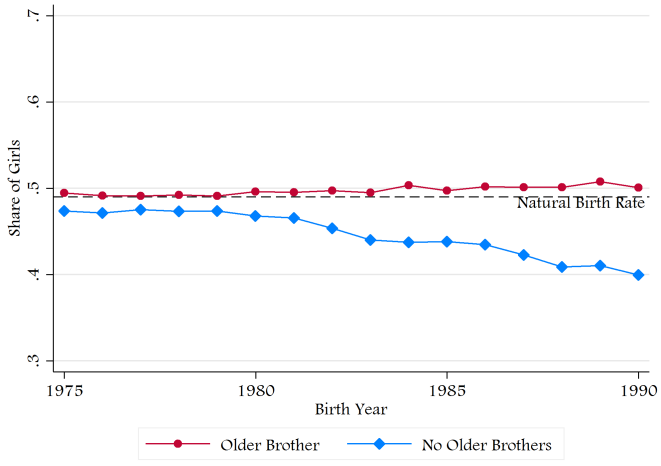
Faced with this resistance, the one child policy was somewhat standardised beginning in 1984. From this time, most rural households were allowed an additional child if their first child was a daughter—the 1.5 child policy—and a number of other exemptions were carved out. Minorities were also brought into the 1CP, although they were usually allowed a second, and sometimes even third, child. Despite this liberalisation, the 1CP appears to have been successful in further reducing total fertility in China: to 2.3 births per woman in 1990 and 1.5 by 1998

Throughout it's existence, the 1CP has been enforced (although not exclusively so) by the imposition of fines and 'fees'.[8] After the initial period, guidance for the level of fines has been set at the provincial level, and fines have nominally been proportional to household income (although due to the challenges associated with accurately measuring income, fines were increasingly standardised). Ebenstein (2010) has shown that, at the province level, the increase in sex selection was inversely proportional to the severity of fines, suggesting variation in the burden of the fines had real consequences for fertility. However, because there was a strong regional component to the intensity of the fine regime, these findings could also be driven by pre-existing differences in son preference interacting with the arrival of sex cheap sex detection technology. Regardless, anecdotally, the relatively well off appear to have been willing to pay the fines (Scharping, 2013, pp. 142-143) which suggests that holding the regime of fines and sanctions roughly

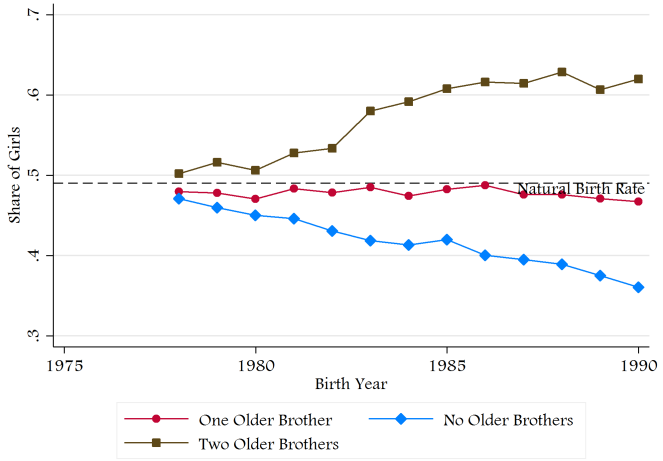
[8]Other sanctions have included, non-adjustment of land/living space for increased family size, exclusion from health, welfare and other social services, reduced rations and expulsion from the communist party.



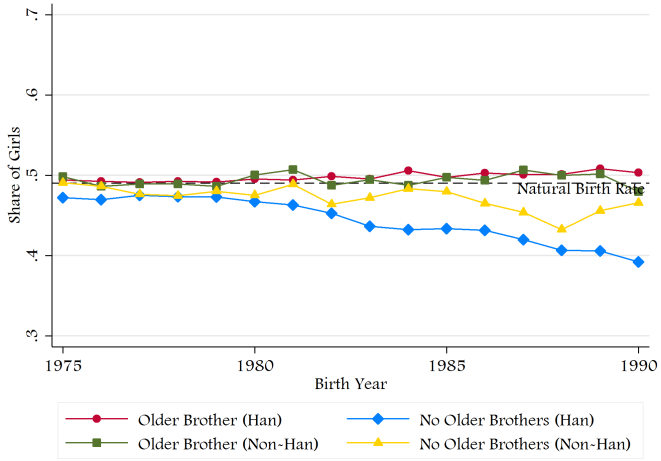
(3.1a) First Born Children



(3.1b) Second Born Children



(3.1c) Third Born Children



(3.1d) Second Born (Han vs. non-Han)

Figure 3.1: Share of Girls in Birth Year Cohorts Conditional on Birth Order, Family Composition and Ethnicity. (Source: Calculated from the 1% Sample of the 1990 Population Census)

constant—for instance, within a province—incomes may interact with the effectiveness of the 1CP.

3.2.2 Sex ratios in China

While Chinese fertility remained high, sex ratios for newborns and young children remained close to the natural rate of around 1.06 boys for every girl. In the 1953 and 1964 censuses, there were 1.05 and 1.04 boys age below 1 for each girl reported. By the early 1980's there were 1.08 boys for every girl, by the end of the 1980's, 1.11, and by 1995, 1.16 (figures from Scharping, 2013, Table 32). Given that fertility declined dramatically in the 1970's but sex ratios at birth barely moved, it is hard to make the case that fertility transition described above was the sole cause of these changes. In fact the timing of the increase suggests that the availability of sex detection technology may have been the proximate cause for the increase (Chen et al., 2013; Lin et al., 2014). This chapter will ask whether the change in fertility during the 1970s, and to a lesser extent through the 1980s and 1990s were instrumental in generating the requisite latent demand for sex selection.

As documented by Yi et al. (1993), Ebenstein (2007) and others, these biased sex ratios are driven *entirely* by gender imbalance in higher order births. Figures 1-3 provide a demonstration of this. Using unadjusted data from the 1990 census (so these data also include differential mortality), and conditioning on the gender of older siblings, I have plotted the share of girls in the population in a given birth cohort conditional on being the firstborn child (figure 3.1a); second born child (figure 3.1b); and third born child (figure 3.1c). For first births, second births to families with a boy, and third births to families with a boy and a girl, the share of girls is extremely close to the natural share (modulo differential childhood mortality). However, for families with a single girl, or two girls, a substantial and growing bias in favour of boys is immediately apparent. Interestingly households with two boys have a significant bias in favour of girls. However, because more families choose

to have second and third children if they have no boys than if they have no girls, the overall effect of the sex selection is to strongly increase the share of boys.

3.2.3 Agricultural reforms, incomes and the One Child Policy

The fines associated with the 1CP bear more heavily on the poor than the rich. However, because the rich may have different preferences for fertility and sons, we cannot compare the choices of rich and poor to explore the link between the 1CP, fertility and biased sex ratios. This chapter uses plausibly exogenous variation in incomes provided by China's agricultural reforms to avoid the endogeneity of income and preferences.

China's agricultural reforms, beginning in late 1978, marked the start of the reform era. They resulted in substantial increases in agricultural productivity and output, and their successes paved the way for non-agricultural reform and China's economic successes of the next three decades. The reforms improved incentives, by decommunalising agriculture and increasing the prices faced by farmers (McMillan et al., 1989; Lin, 1992), as well as by improving the allocation of crops to land by *de facto* liberalising planting decisions (Lardy, 1983, or chapter 1).[9]

This chapter will exploit the fact that the reforms effectively liberalised the planting of cash crops. This liberalisation increased agricultural output in parts of China relatively suited to those crops, as demonstrated in chapter 1. The reforms effectively liberalised the planting of cash crops because pre-reform agricultural institutions were biased in favour of grain production. Prior to the reforms, rural areas were only allowed 'to produce economic crops or raise animals, [...] only after they had achieved basic self-sufficiency in food grains' (Lardy, 1983, p. 49). Self sufficiency was enforced through the state's monopoly on

[9]For the interested reader, there is a huge literature on the reforms. See e.g. Lardy (1983); Perkins (1988); Sicular (1988); Oi (1991); Huang (1998).

trade in agricultural produce and compounded by the low productivity of Chinese agriculture, which kept most rural households close to subsistence. Communes and production teams were also often required to deliver quotas of grain to the state, and the political success of rural party cadres was linked to the production of grain.

China's reforms reduced the emphasis on grain production and improved the incentives faced by farmers. As a consequence, agricultural output expanded rapidly. Grain output increased by 5 percent per-year between 1978 and 85, compared to 2.4 percent per-year between 1952 and 1978. Output of cash crops increased even more rapidly: cotton by 19.2 percent per-year, sugar by 12.3 percent and oil-crops by 14.8 percent, compared to 2, 4.5 and 0.8 percent per year pre-reform. Because farmers with land suited to cash crops were best placed to benefit from planting cash crops, agricultural output grew fastest in areas suited to cotton and oilseeds.

3.3 Conceptual Framework

To motivate the empirical analysis, I provide a simple economic model of fertility at the household level in the tradition of Becker (1960). Households have preferences over consumption $u(c)$, where u strictly increasing and strictly concave, and family size n. In addition to these standard elements, households also prefer to have at least one son and receive a payoff of γ_b if they do so (perhaps capturing the role of sons in providing retirement income documented in Ebenstein and Leung, 2010; Ebenstein, 2014). They are also able to to engage in sex selection if they are willing to pay a psychic cost γ_s capturing the disutility associated with sex selective abortion or infanticide. Lifetime utility is

$$U = u(c) + n\gamma_n + b\gamma_b - s\gamma_s \tag{3.1}$$

where b and s are dummy variables indicating the presence of one or more sons and whether the household has engaged in sex selection. I

restrict γ_n, γ_b, $\gamma_s > 0$. Households maximise their utility facing lifetime budget constraint

$$c = w + \left(1 - \frac{n}{\psi}\right) w^* - \mathbb{1}(n > 1)(n-1)F \tag{3.2}$$

where w is the male wage, w^* the female wage, $1/\psi$ is the amount of time spent out of the labour force due to childbirth and childrearing, and $F > 0$ are fines imposed for each child in excess of one. Under the 1.5 child policy, the system of fines in the model approximate the situation faced by urban households with no children or rural households which already have a daughter.

Unlike households in the simplest models of fertility, households here have preferences over the gender of their children and the ability to choose that gender. This means that fertility decisions should be made sequentially. Let the household have $N \leq \psi$ opportunities to have a child. In each period the household chooses whether to have a child and, then if they choose to have a child, whether to engage in sex selection. For simplicity, let the probability of having a boy in the absence of sex selection be equal to $1/2$ and assume that sex selection works perfectly and guarantees a child of the chosen sex.

The solution to the households fertility problem can be solved by backward induction. For ease of exposition, and with minimal loss of generality, let $N = 2$; the household can have at most two children. Given the costs and benefits of sex selection, households will only sex select in favour of a girl if the Sex Selection Condition holds

$$\gamma_c < \frac{\gamma_b}{2} \tag{3.3}$$

as sex selection is costly, if parents do sex select they only do so on their final child (and only if they don't already have a boy). Finally, because a first boy is more valuable than a second, a second child has higher benefit if the first is a girl.

Table 3.1: Fertility Strategies

Strategy	Payoff
High Cost of Sex Selection $\left(\gamma_c > \frac{\gamma_b}{2}\right)$	
H1: Have no children	$u(w + w^*)$
H2: Have one child	$u(w + (1 - \frac{1}{\Psi})w^*) + \gamma_n + \frac{1}{2}\gamma_b$
H3: Have a child, if it's a girl have another one	$\frac{1}{2}\left[u(w + (1 - \frac{1}{\Psi})w^*) + u(w + (1 - \frac{2}{\Psi})w^* - F)\right] + \frac{3}{2}\gamma_n + \frac{3}{4}\gamma_b$
H4: Have two children	$u(w + (1 - \frac{2}{\Psi})w^* - F) + 2\gamma_n + \frac{3}{4}\gamma_b$
Low Cost of Sex Selection $\left(\gamma_c \leq \frac{\gamma_b}{2}\right)$	
L1: Have no children	$u(w + w^*)$
L2: Have one child and select a boy	$u(w + (1 - \frac{1}{\Psi})w^*) + \gamma_n + \gamma_b - \gamma_c$
L3: Have a child, if it's a girl have another one and select a boy	$\frac{1}{2}\left[u(w + (1 - \frac{1}{\Psi})w^*) + u(w + (1 - \frac{2}{\Psi})w^* - F)\right] + \frac{3}{2}\gamma_n + \gamma_b - \frac{1}{2}\gamma_c$
L4: Have two children, if the first is a girl select a boy for the second	$u(w + (1 - \frac{2}{\Psi})w^* - F) + 2\gamma_n + \gamma_b - \frac{1}{2}\gamma_c$

Depending on the parameters, there are four basic fertility strategies regardless of whether (3.3) holds: (1) have no children; (2) have one child; (3) have two children if the first is a girl, otherwise have one child; and (4) have two children. Table 3.1 describes the full set of strategies and the associated payoffs. If the Sex Selection condition holds, households select the sex of their *last* child.

The model has the following comparative statics with respect to fertility. Higher male incomes, w, are associated with higher fertility. Higher female incomes, w^*, have an ambiguous effect on fertility: the income effect increases the demand for children, but the substitution effect increases their relative price. Given the budget constraint, the income effect is likely to dominate at relatively low levels of fertility, perhaps as in 1980's China, whereas the substitution effect dominates at high levels of fertility. This is consistent with the fertility transitions observed in the developed countries, where increases in women's incomes have been accompanied by reductions in total fertility (Becker, 1965; Willis,

1973; Heckman and Walker, 1990). A more severe One Child Policy, F, reduces fertility as one would expect, while higher utility from children, γ_n, and boys, γ_b, have opposite effect. Falls in the cost of sex selection encourage having a single child relative to other options. As relatively few households are childless, this suggests that the rollout of diagnostic ultrasound may have contributed to fertility decline during the 1980's.

The model has the following comparative statics with respect to sex selection. If the cost of sex selection is high, then households never engage in sex selection. If it is low, then higher male incomes will tend to increase fertility. Whether this increases or decreases sex selection depends on whether most of the increase in fertility is due to the extensive margin effect of formerly childless couples deciding to have children (which increases sex selection) or the intensive margin effect of couple increasing their total fertility (which reduces it). Given that relatively few couples are voluntarily childless in China, it is likely the intensive margin effect dominates and sex selection falls. As with fertility, the effect of increases in female income are ambiguous. Falls in the cost of sex selection, γ_c, increase the propensity for sex selection (as shown in Chen et al., 2013; Lin et al., 2014). Consistent with the findings of Ebenstein (2010), the 1CP increases sex selection, the more so when fines F are high. Falls in preferences for children, γ_n, increase sex selection provided the main margin of adjustment is from two children to one, rather than one child to none. Declines in son preference unambiguously reduce sex selection.

The predictions of this simple model are broadly consistent with the findings of most other papers considering the relationship between fertility, sex selection, the one-child policy and China's missing women. If the mechanism underpinning the model is correct, increases in incomes due to China's agricultural reforms are also likely to have increased fertility and reduced the demand for sex selection. These are the two main predictions I take to the data. I will also verify that parental education,

a marker for income, decreases fertility much more in mothers than in fathers.[10]

3.4 Empirics

In this section, I first explore whether households more able to afford the fines associated with the 1CP had different fertility behaviour. I then use the fact that they do, to ask whether fertility transition had a causal effect on the increasingly unbalanced sex ratios observed in China, India and many other countries in South and East Asia.

The model above describes a world where incomes are a constraint on fertility, as we might expect them to be under the 1CP. Because incomes are likely endogenous to preferences over fertility and sons, we cannot simply compare the fertility decisions of rich and poor. Instead, I obtain variation in incomes using a natural experiment provided by China's agricultural reform. In particular, I will use the fact that parts of China suited to growing cotton and oilseeds were better placed to benefit from the liberalisation of their planting than areas suited to grain, and as a result, had higher post-reform income growth.

The analysis will thus proceed in three steps. The first step is to confirm the findings of Chapter 1, and show that counties of China suited to cash crops did benefit more form the reforms. Next, I test whether women residing in these counties increased their fertility relative to their counterparts elsewhere. Finally, I explore the gender composition of these births.

3.4.1 Incomes

The first step of my analysis verifies that counties endowed with land suited to cash crops did indeed benefit more from China's agricultural

[10] That it reduces fertility for males in contradiction to the predictions of the model, is likely due to the unmodelled relationship between preferences between cultural preferences for fertility and incomes which the variation in incomes below is intended to allow me to avoid.

reforms. I estimate the following difference-in-differences specification comparing the post-reform income growth and increases in primary GDP between areas more or less suited to cash crops

$$Y_{it} = \alpha_i + \gamma_t + \beta(Suitability_i \times Post_t) + \varepsilon_{it} \tag{3.4}$$

where Y_{it} is either net rural income per capital or GDP per capita, α_i are county fixed effects, γ_t are province-time fixed effects, $Suitability_i$ is my normalised measure of suitability, and $Post_t$ is a dummy for years after the reforms. These fixed effects control for all time invariant differences between counties as well as differential province level economic performance.

The income data is from China's Provincial Anniversary Yearbooks. Although most provinces produced Anniversary Yearbooks, only a subset of them provided historical statistics at the county-level before and after the reforms. In all, I have comparable data for most of Gansu, Guizhou, Hebei, Jiangxi, Xinjiang and Zhejiang, and for some prefectures Sichuan and Shanxi. Fairly balanced data is available for the years 1970, 1978, 1985, 1990 and 1995.

To identify the parts of China suited to cash crops I use the measure of suitability developed in Chapter 1. This measure defines suitability at location ι as the ratio of the value of output in cash crops relative to that in grain

$$SCC_\iota = \frac{\max\{\Psi_{c\iota} p_c\}_{c \in \mathbb{C}}}{\max\{\Psi_{c\iota} p_c\}_{c \in \mathbb{G}}} \tag{3.5}$$

where p_c is the price of crop c, Ψ_c yield and $\mathbb{C}$ and $\mathbb{G}$ are the set of cash crops and grains respectively. Because the measure is relative, it captures the proportional gains from switching to cash crops. I briefly describe the key inputs into the measure here, but for a fuller discussion of the merits of each input see Chapter 1.

The empirical implementation uses the measure uses above-quota prices from Sicular (1988) for the year 1978. Above-quota prices are the prices faced by farmers for deliveries to the government in excess of

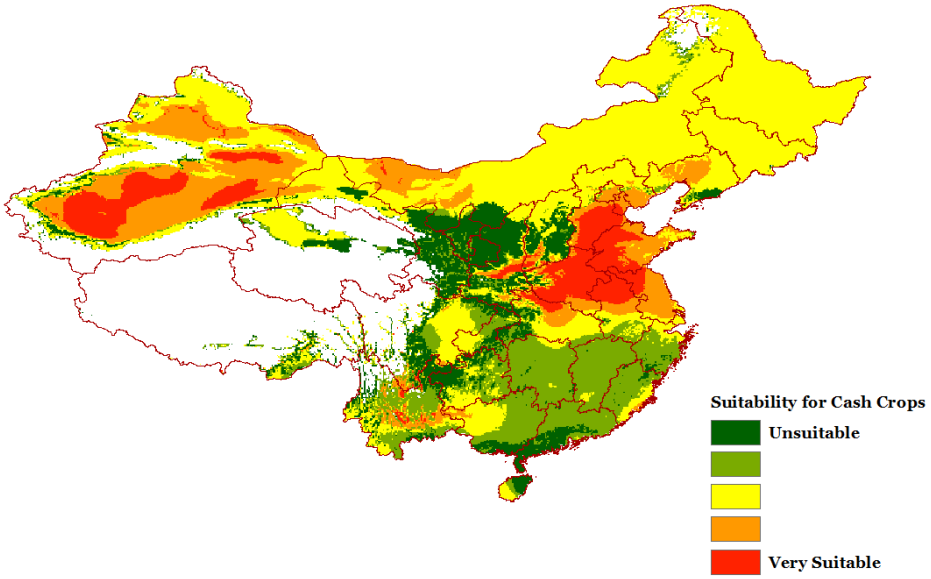


Figure 3.2: Suitability for Cash Crops

their mandated quotas—the marginal price faced by farmers. I use prices from 1978 which have the virtue of preceding the change in agricultural output which followed the reforms. I obtain productivities from the Food and Agriculture Organisation's Global Agro-Ecological Zones (GAEZ) which provides theoretical estimates of gross physical output per hectare under optimal growing conditions at a high spatial resolution.[11] The productivities are based on agronomic models which give measures of potential crop yield based on climatic conditions, soil type, elevation and gradient. The data provides productivities for a number of scenarios, allowing for various level of inputs (fertiliser use, mechanisation, modern seed varieties) and irrigation. As irrigation is widespread in China, I use the productivities based on 'intermediate inputs' and 'irrigation'.

[11] In Beijing a cell represents an area about 6.5km square, cells are larger towards the equator, so in Shanghai a cell is approximately 8km square. Within economics, the use of the GAEZ data was pioneered by Nunn and Qian (2011), and the data has been used subsequently by several authors including Costinot and Donaldson (2014); Bustos et al. (2014)

Figure 3.2 is a map depicting land suitability to cash crops for the whole of China. Significant variation exists both across and, crucially for my empirical strategy, within provinces. Because the finest geographic unit I can assign an individual to in the census is a county, I aggregate the cell level measure to the county level by taking the simple average of cell midpoints within the county $SCC_i = n_i^{-1} \sum_{\iota \in i} SCC_\iota$ where n_i is the number of fertile cell midpoints in county i. County boundaries for the 1990 census were obtained from University of Michigan China Data Center (2006).

Results for rural incomes

Table 3.2 contains estimates of the relationship between my measure of suitability and post reform income growth at the county level. Both GDP per capita and net rural income per capita grew faster in counties best placed to benefit from planting cash crops (Columns 1 and 3). A 1 standard deviation increase in suitability for cash crops is associated with an additional 13% increase in GDP per capita after the reforms and a 20% increase in net rural income per capita (comparing 1985, 1990 and 1995 to 1970 and 1978). The estimated coefficients are significant at the 10% and 1% level respectively.[12]

My baseline specification includes county and province-by-time fixed effects to allow for differential regional trends and time invariant differences in incomes by county. If I omit the county fixed effects, I can include suitability for cash crops directly, and check whether suitability was correlated with incomes prior to the reforms. Columns 2 and 4 provide these results: suitability for cash crops was essentially uncorrelated with incomes before the reforms. This indicates that the gains from specialising in cash crops will have resulted in the residents of these counties becoming richer than those living in places less suited to cash

[12]Standard errors are two way clustered (Cameron et al., 2011) at the prefecture (the administrative division above the county) and the province-by-time levels to allow for autocorrelation of errors over time and space.

Table 3.2: Rural Incomes

	Ln GDPpc		*Ln Rur. Ypc*	
	(1)	(2)	(3)	(4)
Suitability for Cash Crops × Post 78	0.121*	0.135*	0.187***	0.165**
	(0.064)	(0.075)	(0.045)	(0.077)
Suitability for Cash Crops		0.008		-0.050
		(0.066)		(0.083)
Observations	2829	2829	2401	2401
Counties	615		530	
County FE	Yes		Yes	
Province x Year FE	Yes	Yes	Yes	Yes

Robust standard errors two-way clustered (Cameron et al., 2011) at the prefecture and province-by-time level to allow for autocorellation over time and space (*** p<0.01, ** p<0.05, * p<0.1). County level data on Net Rural Income Per Capita and Primary GDP obtained from 50th and 60th provincial anniversary yearbooks. Data covers the years 1970, 1978, 1985, 1990 and 1995 and counties in Gansu, Guizhou, Hebei, Jiangxi, Jiangsu (not Primary GDP), Xinjiang, Zhejiang (not Rural Income) and parts of Shanxi and Sichuan. Suitability for cash crops is the (standardised, county or province average) ratio of the value of output of the best cash crop to the value of output of the best grain crop.

crops, and hence more able to afford the fines associated with breaching the 1CP.

The lack of a pre-existing correlation also suggests that prior to the reforms, these areas were reasonably similar in economic terms, which is supportive of the idea that suitability for cash crops was distributed throughout China in a manner as good as random. In a similar vein, Chapter 1 contains a large number of robustness checks for similar empirical results; confirmation that counties more or less suited to cash crops were following parallel trends in a wide range of economic outcomes in the years prior to the reforms; and shows that counties suited to cash crops actually started to grow more cash crops in the wake of the reforms. For brevity, I do not replicate these types of results here.

3.4.2 Fertility

The second step is to establish whether higher incomes did indeed allow households to increase their fertility under the 1CP. I estimate the effect of incomes on fertility using a difference-in-difference strategy exploiting only within woman variation. My baseline estimating equation is the following linear probability model

$$Birthevent_{it} = \alpha_i + \gamma_{jt} + \phi Birthevent_{it-1} + \beta \left(SCC_i \times Post_t \right) + x_{it}^{'}\theta + \epsilon_{it} \tag{3.6}$$

where α_i is a woman specific FE, γ_{jt} is a province-by-time FE allowing for differential trends in fertility by province, SCC_i is the suitability for cash crops of the county the woman resides in and $Post_t$ is a dummy taking a value of 1 for years after 1981.[13] I allow for a vector of time varying controls, x_{it}, including a full set of province-by-age fixed effects and controls for family composition. In my baseline specification, errors are clustered at the province level, allowing for auto-correlated errors over time and space. I create the fertility panel using the set of married women in the 1990 I census. I focus on women who are either the head of household or the spouse of the head of household spouse and were born between 1945 and 1959. These are the women who I am able to reconstruct a full fertility history for. Table 3.3 contains summary statistics for this data.

One potential issue is that higher incomes could be related to fertility other than through an increase in the demand for children. Particularly, higher incomes could be associated with earlier marriage, which—given the rarity of childrearing out of wedlock in China—would lead to an increase in fertility in the earlier years of life. To the extent that this

[13]The choice of 'treated' and 'non-treated' years is not crucial for my analysis. The reforms were implemented gradually between 1978 and 1984 and for decommunalisation at least, the bulk of the changes took place between 1981-83 (Lin, 1992). In light of this1981 provides a reasonable final 'pre-reform' year. Appendix table B.2 provides supplementary results based on alternative cutoff years with quite similar results.

Table 3.3: Summary Statistics

x	$\bar{x}$	σ_x	N	$\rho_{x,relval}$
A. Annual Fertility Data (For Section 3.4.2)				
Any Birth	0.111	0.31	13.7m	
- male only	0.058	0.23	13.7m	
- female only	0.052	0.22	13.7m	
- conditional on 1 or more children already	0.096	0.30	9.3m	
- for non-Han mothers	0.138	0.35	795284	
Total Births by Age 40	2.762	1.11	136614	
B. Characteristics of Women in 1990				
At Least Middle School Education	0.362	0.48	3.0m	0.049
Rural Household Registration	0.778	0.42	3.0m	0.003
Han	0.930	0.26	3.0m	0.127
Migrated in Last Five Years	0.036	0.19	3.0m	0.012

Panel A based on fertility history of married women born 1945-1959 as described in Section 3.4.2 (all variables are dummies except total births). Panel B based on all women aged 21-65 in the 1% sample of the 1990 population census (all variables are dummies).

earlier marriage was not driven by higher desired fertility, my estimates will be upward biased. The data in the 1990 census do not indicate that this is likely to be a problem: young women living in counties suited to cash crops are no more likely to be married than those elsewhere and no more likely to have had children, furthermore, the age of young women who are married or have children is uncorrelated with suitability for cash crops.[14]

Results

Table 3.4 Column 1 provides my baseline estimate of the effect of higher incomes on fertility. A one standard deviation increase in suitability

[14]See appendix table B.1 for these results and appendix section B.2.1 for a somewhat extended discussion of them.

for cash crops—my proxy for income—is associated with a post-reform relative increases in the likelihood of a birth of 3.2 percentage points per year. This estimate is significant at the 1% level.[15] The effect size is large, at 28% of the average annual fertility rate in my sample, but equates to a much smaller overall increase in fertility due to the observed negative impact of previous fertility on the likelihood of additional births. Consistent with China's preference for sons, the marginal reduction in fertility due to a boy is greater than that for a girl. Column 2 restricts the sample to women who have already had at least one child and so captures purely the effect on fertility on the intensive margin. Because the sample includes women who have not completed childrearing, the estimate is a lower bound estimate of the intensive margin effect. Nevertheless, the estimated coefficient indicates that at least 2/3 of the effect is due to increases in fertility along the intensive margin and, despite being a lower bound, the intensive margin effect is not statistically significantly different from the full effect estimated in column 1.

Columns 3 and 4 provide estimates for male and female births. The increase in total fertility is split equally, with a one standard deviation increase in suitability associated with a 1.6 percentage point increase in the probability of a male or female birth. Given that China's imbalance in births, an equal increase in male and female births represents a reduction in gender bias. Consistent with gender discrimination, the effect of past births effect the likelihood of new male and female children quite differently: more boys primarily reduce the probability of male births, more girls only reduce the probability of more female births.

As with any difference-in-difference strategy the identification assumption is that of parallel trends. That is, that women living in counties more or less suited to cash crops, would have identical changes in fertility in the absence of the reforms. While it is not possible to verify this

[15] In my baseline specification, standard errors are clustered at the province level. Because the number of provinces (29) is slightly below the number desirable to be reasonably sure of consistency, I also provide my baseline results with errors clustered at the prefecture level (Column 5). The standard errors based on clustering at the prefectural level are significantly smaller.

Table 3.4: Effects on Fertility: Baseline Results

	Dummy for Birth of...				
	Any		Boy	Girl	Any
	(1)	(2)	(3)	(4)	(5)
Suitability for Cash Crops × 1982-1990	0.033***	0.020**	0.017***	0.016***	0.033***
	(0.011)	(0.009)	(0.006)	(0.005)	(0.005)
Had Child The Previous Year Dummy	-0.078***	-0.137***	-0.044***	-0.034***	-0.078***
	(0.007)	(0.010)	(0.004)	(0.003)	(0.003)
Number of Boys	-0.247***	-0.295***	-0.207***	-0.041***	-0.247***
	(0.008)	(0.007)	(0.005)	(0.004)	(0.003)
Number of Girls	-0.182***	-0.227	-0.001	-0.182***	-0.182***
	(0.007)	(0.007)	(0.003)	(0.004)	(0.003)
Woman-Year Observations	13.7m	9.3m	13.7m	13.7m	13.7m
Woman FE	Yes	Yes	Yes	Yes	Yes
Province-by-Time FE	Yes	Yes	Yes	Yes	Yes
Province-by-Woman-Age FE	Yes	Yes	Yes	Yes	Yes
Clustering	Prov (29)	Prov (29)	Prov (29)	Prov (29)	Pref (337)

Robust standard errors clustered at the prefecture or province level to allow for autocorrelation of errors over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised) relative suitability of cash crops compared to grains in the county the mother lives. The other variable relate to past fertility history. The sample consists of a panel of married women born between 1945 and 1959 and their fertility events for years between 1973 and 1990. Column 1a restricts this sample to women who have already had one child. The fixed effects allow for province specific differences in fertility patters over the life cycle, province specific trends in overall fertility and time invariant woman specific fertility differences

assumption directly, we we can use the pre-reform years as a placebo test of the parallel trends assumption. To implement this, I estimate a version of Equation 3.6 estimating a coefficient on suitability for each year in the data

$$Birthevent_{it} = \alpha_i + \gamma_{jt} + \phi Birthevent_{it-1} + \sum_{s \neq 1973} \beta_s \left(SCC_i \times I\{Year == s\} \right) + \epsilon_{it} \tag{3.7}$$

as the reforms begin in late 1978, we would expect $\beta_t = 0 \; \forall \, t < 1978$. Any effects of the reform ought to appear gradually after 1978, with the full effect potentially not observed until a few years after the completion of the agricultural reforms in 1984.

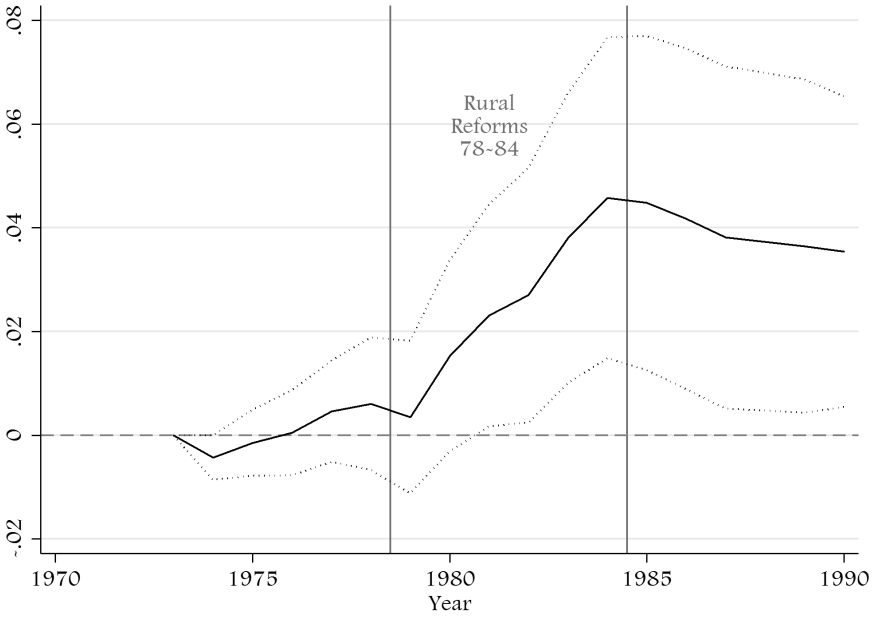


Figure 3.3: Effect of Suitability for Cash Crops on Fertility 1973-1990 (and associated 95% confidence intervals.)

Figure 3.3 plots these estimated coefficients and associated 95% confidence intervals for each year in the data. Prior to the reforms there were no differential trends in fertility, whereas after the reforms, women in areas suited to cash crops experienced a substantial increase in their relative fertility. This is consistent with the parallel trends assumption.

The framework provided in Section 3.3 suggested that higher incomes for women would likely reduce fertility, whereas higher incomes for men would probably increase it. The census data do not include a measure of household or individual income, however, I can observe parental education, which is likely to be closely related to income. Unfortunately, even more than income itself, education is likely to be a strong correlate of weaker cultural preferences for children. With this in mind, given that the opportunity cost of having children in terms of lost income is much higher for women than for men, given this, we should expect the relationship between education and fertility to be *more negative* for women than for men. Table 3.5 provides these results. High education for either

Table 3.5: Effects on Fertility: Education

	Any Birth Dummy			
	(1)	(2)	(3)	(4)
Suitability for Cash Crops × 1982-1990	0.017*** (0.004)	0.018*** (0.004)	0.018*** (0.005)	0.018*** (0.005)
Mother Attended Junior Middle School or Higher		-0.033*** (0.002)		-0.030*** (0.002)
Father Attended Junior Middle School or Higher			-0.016*** (0.001)	-0.008*** (0.001)
Woman-Year Observations	13.7m	13.7m	12.7m	12.7m
Woman FE	*No*	*No*	*No*	*No*
County FE	Yes	Yes	Yes	Yes
Parent's Registration Status FE	Yes	Yes	Yes	Yes
Parent's Ethnicity FE	Yes	Yes	Yes	Yes
Province-by-Time FE	Yes	Yes	Yes	Yes
Province-by-Mother-Age FE	Yes	Yes	Yes	Yes

Robust standard errors clustered at the prefecture or province level to allow for autocorrelation of errors over time and space (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). Suitability for cash crops is the (standardised) relative suitability of cash crops compared to grains in the county the mother lives. The other variable relate to past fertility history. The sample consists of a panel of married women born between 1945 and 1959 and their fertility events for years between 1973 and 1990 (including both mothers and non-mothers). The fixed effects allow for province specific paths of fertility by age, province specific trends in overall fertility and time invariant county, parental ethnicity and registration specific fertility differences (separate sets of dummies for each parent). All specifications include controls for fertility history as in table 3.4.

parent negatively predicts fertility. (The measure of 'high education' is attendance at junior middle school or higher, a level achieved by just over a third of women and just under half of men.) However, when included together, maternal education is the principle driver of this lower fertility. This is consistent with the opportunity cost theory of fertility.[16]

Because fertility restrictions associated with the 1CP are more stringent on Han Chinese than ethnic minorities, the fertility of minorities ought to be less constrained by the 1CP and hence less affected by income increases. Thus comparing the effect on Han and non-Han households provides an additional, albeit imperfect, placebo test of the effect of income on fertility.[17] If the increase in fertility was primarily due to earlier household formation or geographically correlated shocks in taste, then we would expect the same effect on both Han and non-Han households. However, if the increase in fertility was due to he fertility restrictions embodied in the 1CP we would expect non-Han households to be relatively unaffected.

Table 3.6 provides this placebo test. Column 1 restates my baseline results. Column 2 restricts the sample to Han mothers. Column 3 restricts the sample to non-Han. Fertility increases strongly in Han households and the estimated coefficient is significant at the 1% level. In non-Han households, the effect on fertility is one-third of the size and statistically insignificant. These results are consistent with higher incomes alleviating constraints on fertility due to the 1CP, particularly for households that are most constrained.

[16] Because parental education are time invariant in my data, I can no longer include woman specific fixed effects. I instead include a battery of county, parental registration and ethnicity fixed effects. This change in specification attenuates the coefficient on my main variable of interest but it remains substantial and statistically significant at the 1% level.

[17] The imperfectness stems stems form the fact that non-Han households may have been differentially positioned to benefit from growing cash crops. If they benefitted more, then they would be relatively more able to afford the fines associated with their less stringent treatment in the 1CP, so they might nevertheless choose to increase their fertility. However, if they benefitted less, then to the extent that the main results are due to earlier household formation, this bias would not be replicated in this test.

Table 3.6: Effects on Fertility: Placebo Test

	Any Birth Dummy		
	(1)	(2)	(3)
Suitability for Cash Crops × 1982-1990	0.033*** (0.011)	0.035*** (0.011)	0.012 (0.012)
Mother-Year Observations	13.7m	12.9m	0.8m
Mother FE	Yes	Yes	Yes
Province-by-Time FE	Yes	Yes	Yes
Province-by-Mother-Age FE	Yes	Yes	Yes
Ethnicity	All	Han	Non-Han

Robust standard errors clustered at the province level (29) to allow for autocorrelation of errors over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised) relative suitability of cash crops compared to grains in the county the mother lives. The sample consists of a panel of married women born between 1945 and 1959 and their fertility events for years between 1973 and 1990. Column 2 and 3 restrict the sample to Han and non-Han women respectively. The fixed effects allow for province specific paths of fertility by age, province specific trends in overall fertility and time invariant woman specific fertility differences. All specifications include controls for fertility history as in table 3.4.

The results of this second placebo test also mitigate against a another potentially important alternative explanation for fertilely change: that producing cash crops may have changed the calculus in the quantity-quality tradeoff (e.g. Becker and Lewis, 1974). For this to be a concern, shifting to the production of cash crops ought to have encouraged quantity rather than quality. The classic argument suggests that as the return to skill increases, parents choose to have fewer children which are of higher quality. Thus, if growing cotton were less skill intensive than grain, the calculus could move in favour of quantity. This does not appear to be the case: the distribution of education of workers in cotton is almost identical to that of grain (figure 3.4), with if anything, workers in cotton being slightly more educated.[18] (The intuition provided by this visual inspection is confirmed by an unreported ordered probit regression which

[18]Unfortunately the data do not permit the same comparison with respect to oilseeds.

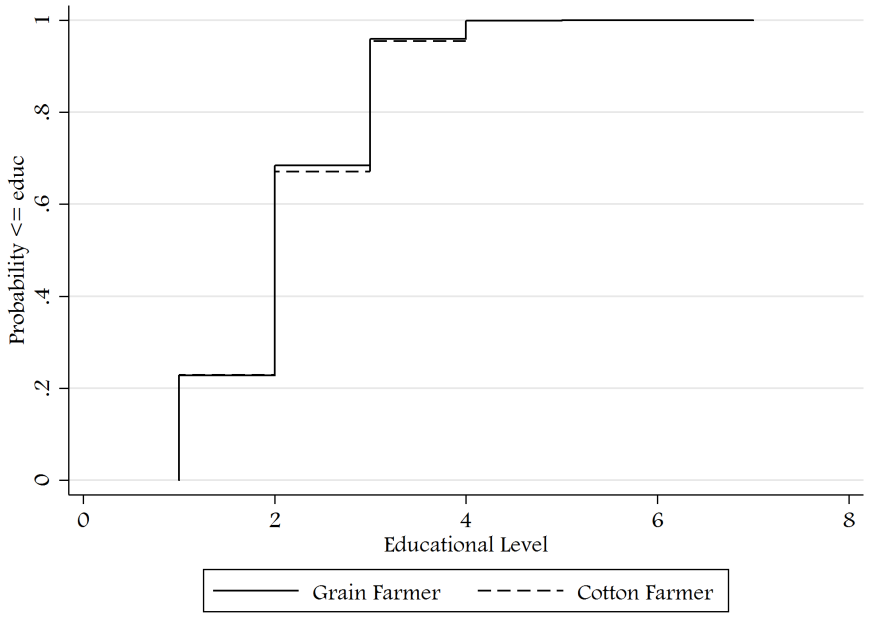


Figure 3.4: CDFs of Educational Levels for Grain and Cotton Farmers (0 ″N/A″ 1 ″Illiterate″ 2 ″Primary″ 3 ″Junior Middle″ 4 ″Senior Middle″ 5 ″Technical School″ 6 ″Junior College″ 7 ″University″)

indicates that workers in cotton have an infinitesimally higher level of education.) As Chapter 1 documents a substantial subsequent increase in non-agricultural output in these areas—activity that is relatively human capital intense—it seems safe to say that, if anything, the returns to human capital is likely to have increased. We might also expect to see the quantity-quality calculus shift towards quantity if the demand for child labour increased, however, perhaps because of the surplus of adult labour in early reform-era China, children do not form a major part of the rural labour force in China (Bowlus and Sicular, 2003).

3.4.3 Sex selection

The level of sex selection increased substantially in 1980's China. This chapter asks whether fertility transition was an instrumental factor in this change. We have seen in the previous section that, within province,

higher incomes relaxed the constraints on fertility due to the One Child Policy and led to higher birth rates. I now ask whether this reduced the level of sex selection.

As shown in figure 3.1, the increased share of boys was entirely due to an increase in the share of boys for higher order births in households that had not already had a boy. I exploit this differential discrimination to allow the use of a triple difference strategy. The first difference is in the timing of the reforms. The second is in geographic suitability for cash crops (my proxy for higher incomes/fertility). The third is the presence of older brothers.[19] To implement the third difference, I restrict my attention to second-born children, as sex discrimination against boys for some third born children would slightly complicate the interpretation of the estimated coefficient.

In practice, my empirical implementation of the triple difference strategy utilises a large set of fixed effects. The estimating equation is

$$Girl_{ijkt} = \alpha_{jk} + \gamma_{jt} + \delta_{kt} + \beta(SCC_i \times Post_t \times NoBrother_i) + \epsilon_{ijkt} \quad (3.8)$$

where α_{jk} are county-by-no-brother fixed effects, γ_{jt} are county-by-birth-year fixed effects, and δ_{kt} are province-birth-year-by-no brothers fixed effects. The outcome variable $Girl_{ijkt}$ is a dummy taking a value of 1 if the child is a girl.

The inclusion of county-by-no-brother fixed effects, allows for time invariant difference in son preference and sex selection at the county level. The county-by-birth-year fixed effects, allow for county-year specific shocks to sex ratios including economic and environmental shocks in-utero and through childhood which differentially effect the survival of boys and girls. For instance, this allows for the fact that male foetuses are more fragile and thus less likely to be born in times of hardship (Andersson and Bergström, 1998). The province-by-birth-year-by-no-brother fixed effects flexibly allow for differential changes in son

[19] A closely related empirical strategy was proposed, but not implemented, by Almond et al. (2013).

preference and sex selection by province. (This last set of fixed effects are the triple difference analogue of province-by-time FE's in a standard difference-in-difference specification.)

I impute the required data from the 1% sample of the 1990 population census. Because my analysis is of cohort in 1990 rather than actual births, it is important to highlight that any effect on the gender uncovered captures both sex selection at birth *and* discrimination between birth and 1990. While my data do not allow me to estimate the effect of only antenatal sex selection, Anderson and Ray (2010) show that while China has hugely skewed sex ratios at birth, the level of discriminatory mortality during childhood is low. In light of this, my empirical results are likely to be driven by discrimination before birth and throughout the chapter and I use the term 'sex selection' as a synonym for total discrimination.

The individuals of interest are those born in the years before and after the reform who have one older sibling. I recover this information from the presence of other children of household heads in the same household. This approach necessitates a number of restrictions on the set of births used. First, I can only use households with a unique household head and spouse, which precludes the possibility of using births to households in communal living arrangements. Second, because in the census HH structure is defined relative to the household-head, I restrict myself to the children of HH heads: there are no grandchildren or cousins of HH heads in the sample. Third, I exclude children in households which have migrated in the five years prior to the census as I don't know where they migrated from, and hence, am unable to determine how much they benefited from the reforms prior to migration.[20]

It has sometimes been argued that China's demographic data undercount the youngest children, and in particular, young girls, the consequence of this being that sex ratios at birth look worse than they really are. Banister (2004, p. 20) reviews the evidence for this

[20]Unfortunately, the census does not include complete information on migration history, so some households may have migrated before 1985. However, migration was very low during this period so any bias from this error is likely to be minimal.

proposition and concludes that 'in the 1990 census [the primary source of demographic data employed in this chapter], there was no more undercounting of young children of one sex than the other'. Given this, and the empirical strategy employed, any undetected undercounting is unlikely to be problematic.[21]

Results

Table 3.7 column 1 provides my baseline triple-difference result. Counties with more rapid post-reform increases in incomes and fertility, experienced relative falls in gender discrimination at birth after the reforms. A one-standard deviation increase in suitability for cash crops increases is associated with 2.4 percentage point increase in the probability of a second born child being a girl if it has an older sister (when discrimination commonly occurs) compared to the probability of having a girl when the household already has a boy (and there is little sex selection). This estimate is significant at the 1% level and should be compared to an overall deficit in the number of girls of between 8 and 10 percentage points.[22]

[21] Even, if there were some undercounting of girls, this would only be a problem for my empirical results if the undercounting was (a) related to whether the firstborn child was male or female, and (b) correlated with suitability for my proxy for post-reform income growth.

[22] In my baseline specification, standard errors are clustered at the province level. Because the number of provinces (29) is below the number desirable to be reasonably sure of consistency, in column 5 I provide my baseline results with errors clustered at the prefecture level.

Table 3.7: Effects on Sex Ratios: Baseline Results

	Girl Dummy				
	(1)	(2)	(3)	(4)	(5)
SCC × No	0.024***	0.024***	0.024***	0.022***	0.024***
Brother × Born 1982-1990	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)
Observations	890908	890908	830972	691516	890908
County-by-Birth Year FE	Yes	Yes	Yes	Yes	Yes
County-by-No Brother FE	Yes	Yes	Yes	Yes	Yes
Province-by-Birth-Year-by-No Brother FE	Yes	Yes	Yes	Yes	Yes
Clustering	Prov (29)	Prov (29)	Prov (29)	Prov (29)	Pref (337)
Mother Controls		Yes	Yes		
Father Controls			Yes		

Robust standard errors clustered at the province or prefecture level to allow for autocorrelation of errors over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. No Brothers is a dummy taking a value of 1 indicating that at birth the individual had no male older siblings. Born after 1982-1990 is a dummy indicating that the individual was born after 1981. SCC is my normalised measure of suitability for cash crops. The sample is all individuals born between 1973 and 1990 with one older sibling in the 1% sample of the 1990 Chinese Population Census excluding Hong Kong, Macao and Tibet as well as a small number of individuals which could not be matched to geographic data and a small number of other exclusions discussed in the main text. Column 4 also excludes children from households where the number of children is not precisely equal to the number of births. Mother and Father Controls include sets of dummies for age, education (7 categories) and industry of employment (316 categories).

Columns 2 and 3 introduce controls for maternal and paternal age, education and industry, by including a full set of dummies for each. The estimated coefficients on my variable of interest are completely unchanged.

Because birth order is imputed from a child's age relative to the other children in the household, rather than from information directly provided, it may be imputed with error where one or more children have died or are temporarily or permanently out of the household. I can greatly reduce problems of this type by restricting the sample to children born to households where the number of children present is exactly equal to the number the mother reports ever having been born. Whether this is desirable or not depends on when the child went missing or died. For the younger siblings of children who died in infant hood, with respect to the 1CP it is as if the second born child is the first born, and the third born child the second born. Hence, in my baseline specification I choose not to impose this restriction. My results are nevertheless almost completely unchanged if these children are excluded (column 4).

The identification assumption is that of conditional parallel trends. Within a province there would have been no differential change in the probability of a second child with no brothers being born (and surviving) in areas suited to cash crops (relative to those born in places suited to grain), beyond any changes in the sex ratio of those born in families which already had a son. This identification assumption does not require that higher incomes or growing cash crops had no direct effect on the probability that a second child is male, only that the direct effect is the same regardless of the gender of the first child. For instance, changes in sex ratios as a result of higher incomes, changing diets or exposure to pollution, pesticides or fertiliser are only problematic if they affect the gender of second born children conditional on the gender of the first born.

Although it is not possible to directly verify this conditional parallel trends assumption we can use the pre-reform years as a placebo test of the assumption. To implement this, I estimate the triple-difference analogue

Figure 3.5: Triple Difference Estimates of the Effect of Suitability to cash crops on Sex Ratios 1973-1990
(and associated 95% confidence intervals)

of equation 3.7 which allows for a differential effect of suitability for each birth year

$$Girl_{ijkt} = \alpha_{jk} + \gamma_{jt} + \delta_{kt} + \sum_{s \neq 1973} \beta_s \left(Suited_i \times I\{BirthYear == s\} \times NoBrother_i \right) + \nu_{ijkt} \tag{3.9}$$

as the reforms begin in late 1978, we would expect $\beta_t = 0 \; \forall \, t < 1978$. Then as the reforms are implemented between 1978 and 1984 we would expect any effects on sex ratio to begin to appear. However, to the extent that increased demand for sex selection only translated into widespread after the availability low cost sex detection technology, the effect on gender might not be apparent until later in the 1980's.

Figure 3.5 plots the triple-difference treatment effect of suitability on the sex of second born children for each year in the data. Prior to the reforms there were no differential trends in coefficients, whereas after

the reforms a substantial differential effect becomes apparent. This is consistent with the key assumption of conditional parallel trends.

Interestingly, the difference in sex ratios only begins to emerge in the mid-1980's, around the end of the reforms rather than during them. This is approximately contemporaneous with the widespread availability of low cost sex detection technology (Chen et al., 2013) and suggestive that the lower demand for sex selection generated by higher fertility only became an important determinant of gender ratios once this demand (or lack thereof) was relatively easy to act upon. However, because of this timing we must be concerned that my proxy for income and fertility growth was correlated with some latent variables affecting the demand for sex selection. We have already seen that incomes are essentially uncorrelated with suitability prior to the reform suggesting that these areas do not differ substantially economically. In table 3.3, I reported correlations between suitability for cash crops and education, registration status, migration and minority status. Only minority status is correlated with any degree of strength: woman are more likely to be Han and less likely to be minorities. Because non-Han Chinese had larger families and were less affected by the 1CP, they are likely to have had weaker latent demand for sex selection, indicating that, if anything, my estimates are probably downward biased.

Table 3.8 once again exploits the fact that fertility restrictions were stricter for Han Chinese than ethnic minorities to provide a quasi-placebo test of the mechanism. Column 1 restates my baseline results. Column 2 restricts the sample to Han. Column 3 restricts the sample to non-Han. Higher incomes (proxied by suitability for cash crops) are associated with more girls amongst Han Chinese but not amongst ethnic minorities. This is consistent with higher rural incomes reducing gender bias only where higher incomes enabled an increase in fertility

Table 3.8: Effects on Sex Ratios: Placebo Test

	Girl Dummy		
	All	Han	Non-Han
	(1)	(2)	(3)
SCC × No	0.024***	0.024***	0.007
Brother × Born 1982-1990	(0.008)	(0.008)	(0.019)
Observations	890908	806811	84097
County-by-Birth Year FE	Yes	Yes	Yes
County-by-No Brother FE	Yes	Yes	Yes
Province-by-Birth-Year-by-No Brother FE	Yes	Yes	Yes

Robust standard errors clustered at the province level to allow for autocorrelation of errors over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. No Brothers is a dummy taking a value of 1 indicating that at birth the individual had no male older siblings. Born after 1982-1990 is a dummy indicating that the individual was born after 1981. SCC is my normalised measure of suitability for cash crops. The sample is all individuals born between 1973 and 1990 with one older sibling in the 1% sample of the 1990 Chinese Population Census excluding Hong Kong, Macao and Tibet as well as a small number of individuals which could not be matched to geographic data and a small number of other exclusions discussed in the main text. Column 1 include all births, column 2 only Han births and Column 3 only non-Han births.

Women's labour market outcomes

If women had a comparative advantage in growing and distributing cotton and oilseeds, specialisation in these crops may have affected their relative labour market prospects. While the differential labour market prospects do not appear to be an important factor in cross-national or cross ethnic differences in sex selection (Ebenstein, 2014), in China, in the early 1980's, increases in women's relative earnings do appear to reduce sex selection (Qian, 2008).[23]

If growing cotton and oilseeds improved women's labour market outcomes, then this would provide an additional explanation for the

[23]One explanation for this apparent inconsistency is that in general improved labour market prospects for women are likely to capture two offsetting effects: a decline in fertility due to the higher opportunity cost of having children which we would expect to increase sex selection and an improvement in the status of women which could reduce it.

observed decline in sex selection (but not for the increase in fertility). One empirical measure of comparative advantage, is the extent to which women are represented in that industry relative to others. On this basis, women do appear to have a comparative advantage in cotton farming than farming as they make up 57% of cotton farmers compared to 47% of all farmers.[24] (Unfortunately, the data do not include oilseed planting as an occupation.) However, it is not clear whether this apparent comparative advantage translates into improved labour market outcomes—cash crop farming may not be the marginal activity for women.

One labour market outcome I can observe is labour force participation. If women's labour market prospects had improved, we might expect higher relative levels of female labour force participation in areas suited to cash crops. This is not apparent in the data. Table 3.9 contains cross sectional regressions of labour force participation on suitability for cash crops of an individuals county of residence, a female dummy and an interaction term based on the 1990 census. Labour market participation is only weakly correlated with female labour market participation in 1990—a one standard deviation increase in suitability as associated with a 1 percentage point increase in participation—and this association is not statistically significant. Adding province specific fixed effects, and fixed effects for household size, education and registration status do not materially affect the estimated correlation.

Of course, if counties suited to cash crops had low female labour market participation prior to the reforms, the cross section could be hiding a differential change in the economic status of women. We have already seen that rural incomes and GDP per capita were uncorrelated with suitability prior to the reform so we would perhaps not expect labour participation to be correlated either. Nevertheless, we can check whether there were differential changes in participation by aggregating

[24] In the 1% sample of the the 1990 census. However there is an almost identical difference in 1982.

Table 3.9: Labour Force Participation: 1990 Individual Cross Section

	In Labour Force Dummy		
	(1)	(2)	(3)
Suitability for Cash Crops	0.005	0.007	0.009
	(0.003)	(0.005)	(0.005)
Suitability for Cash Crops × Female Dummy	0.011	0.011	0.012
	(0.009)	(0.009)	(0.010)
Female Dummy	-0.142***	-0.143***	-0.135***
	(0.016)	(0.016)	(0.015)
Constant	0.879***		
	(0.004)		
N	7.9m	7.9m	7.9m
Province FE		Yes	Yes
Additional Controls			Yes

Robust standard errors clustered at the province level to allow for autocorrelation of errors over time and space (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. The sample consists of individuals over age 18 in the 1% sample of the 1990 Chinese Population Census excluding Hong Kong, Macao and Tibet as well as a small number of individuals which could not be matched to geographic data and a small number of other exclusions discussed in the main text. Additional controls are a full set of dummies for age, household size, registration status and level of education.

Table 3.10: Labour Force Participation: Prefectural DiD

	Female LFP			*M/F LFP*	
	(1)	(2)	(3)	(4)	(5)
SCC × I(1990)	0.010	0.010	-0.010	0.010	-0.003
	(0.006)	(0.008)	(0.013)	(0.008)	(0.010)
Suitability for Cash Crops (SCC)	-0.003				
	(0.012)				
SCC × I(1990) × I(Men)				-0.011	-0.011
				(0.007)	(0.007)
N	458	458	458	916	916
Prefectures	229	229	229	229	229
Prefecture FE		Yes	Yes		
Prefecure-by-Gender FE				Yes	Yes
Time FE	Yes	Yes			
Time-by-Gender FE				Yes	Yes
Province-by-Time			Yes		Yes
Clustering	Prov (27)	Prov (27)	Prov (27)	Prov (27)	Prov (27)

Robust standard errors clustered at the province level to allow for autocorrelation of errors over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (prefectural average standardised using the county s.d for comparability with results elsewhere) ratio of the value of output of the best cash crop to the value of output of the best grain crop. The outcome variable is prefecture and gender specific labour force participation among individuals aged over 18 for a consistent set of prefectures. Data derived from the 1982 and 1990 census microdata, it's construction is described in Appendix sec3:adddata.

the census microdata from 1982 and 1990 to the prefectural level.[25] Table 3.10 contain difference-in-difference estimates of the effect of suitability for cash crops of female labour force participation based on this data. There is no statistically significant effect on female labour force participation and the estimated coefficients are small and of inconsistent sign.[26] In Column 1, we see there there were no pre-existing difference in labour force participation. Columns 2 and 3 add richer sets of fixed effects. Columns 4 and 5, allow for triple differences with respect to male labour force participation.

Thus, although the data suggests that women may have had a modest comparative advantage in cotton, this does not appear to have translated into real differences in labour market outcomes. The role of differential income shocks is hence likely limited. The previous results for fertility are consistent with this. Improved opportunities for women have generally been associated with declining fertility and we have seen the the status of women is correlated with lower fertility in section 3.4.2. Despite this, the higher incomes in this chapter are associated with higher fertility. Although it is not possible to decisively rule out *any* role for gender biased technical change, the pattern of results are much more consistent with a direct link from fertility to sex selection.

3.5 Conclusion

Parts of China more suited to cash crops had faster income growth in the wake of China's agricultural reforms. As a consequence, the residents of these areas were more able to afford the fines associated with the One Child Policy and so increased their fertility. Higher desired fertility

[25] Unfortunately, county level identifiers are not included in the 1982 census micro data (and male and female labour force participation are not provided separately in the county level summary data) so the prefecture is the finest geographic partition available. The construction of the data is discussed in Appendix sec3:adddata.

[26] Because 1982 is somewhat after the start of the agricultural reforms—although, for at least the decommunalisation of agriculture, the bulk of the liberalisation too place between 1982 and 1984—these estimates may be biased towards zero. Given the inconsistent signs this is not too much of a concern.

meant that households were more likely to have a boy by chance and, as a consequence, fewer households felt the need to select the sex of their offspring in order to satisfy their cultural preference for sons.

Interestingly, if we compare the timing of the results, fertility increases almost immediately, but the fall in sex selection mirrors the timing of the rise in sex selection in China as a whole, in that it becomes apparent from the mid 1980's. This is consistent with the timing of the increased availability of pre-natal sex selection documented by Chen et al. (2013). Thus while fertility decline may have driven the demand for sex selection, this latent demand may not have been fulfilled until the price of sex selection became sufficiently low.

The increasingly biased sex ratios observed in Asia thus appear to have been due to the intersection of two trends: fertility transition and the availability of ultrasound. This explains why the fall in fertility in 1970's China was not accompanied by a dramatic change in sex ratios, but suggests that this fall may have been responsible for an increase in latent demand for sex selection that only manifested once the price of sex selection had fallen sufficiently.

Bibliography

Acemoglu, D. and Guerrieri, V. (2008). Capital deepening and nonbalanced economic growth. *Journal of Political Economy*, 116(3).

Aghion, P., Comin, D., and Howitt, P. (2006). When does domestic saving matter for economic growth?

Allen, F., Qian, J., and Qian, M. (2005). Law, finance, and economic growth in China. *Journal of Financial Economics*, 77(1):57–116.

Almond, D., Li, H., and Zhang, S. (2013). Land reform and sex selection in China. *NBER Working Paper 19153*.

Anderson, S. and Ray, D. (2010). Missing women: age and disease. *The Review of Economic Studies*, 77(4):1262–1300.

Andersson, R. and Bergström, S. (1998). Is maternal malnutrition associated with a low sex ratio at birth? *Human Biology*, pages 1101–1106.

Andreoni, J. (1990). Impure altruism and donations to public goods: a theory of warm-glow giving. *The Economic Journal*, pages 464–477.

Attanasio, O. P., Picci, L., and Scorcu, A. E. (2000). Saving, growth, and investment: a macroeconomic analysis using a panel of countries. *Review of Economics and Statistics*, 82(2):182–211.

Au, C.-C. and Henderson, J. V. (2006a). Are chinese cities too small? *The Review of Economic Studies*, 73(3):549–576.

Au, C.-C. and Henderson, J. V. (2006b). How migration restrictions limit agglomeration and productivity in China. *Journal of Development Economics*, 80(2):350–388.

Bai, C.-E., Hsieh, C.-T., and Qian, Y. (2006). The return to capital in China.

Banerjee, A., Duflo, E., and Qian, N. (2012). On the road: Access to transportation infrastructure and economic growth in China.

Banerjee, A. V. and Newman, A. F. (1993). Occupational choice and the process of development. *Journal of Political Economy*, pages 274–298.

Banister, J. (2004). Shortage of girls in China today. *Journal of Population Research*, 21(1):19–45.

Baum-Snow, N., Brandt, L., Henderson, J. V., Turner, M. A., and Zhang, Q. (2012). Roads, railroads and decentralization of chinese cities. Technical report, Working paper.

Becker, G. S. (1960). An economic analysis of fertility. In *Demographic and economic change in developed countries*, pages 209–240. Columbia University Press.

Becker, G. S. (1965). A theory of the allocation of time. *The Economic Journal*, pages 493–517.

Becker, G. S. and Lewis, H. G. (1974). Interaction between quantity and quality of children. In *Economics of the family: marriage, children, and human capital*, pages 81–90. UMI.

Berkowitz, D., May, H., and Nishiokaz, S. (2014). Can state owned enterprises restructure? Theory and evidence from China. *Unpublished Preliminary Manuscript*.

Bowlus, A. J. and Sicular, T. (2003). Moving toward markets? Labor allocation in rural China. *Journal of Development Economics*, 71(2):561–583.

Boyreau-Debray, G. and Wei, S.-J. (2005). Pitfalls of a state-dominated financial system: The case of China.

Brandt, L., Giles, J., and Park, A. (1997). Giving credit where credit is due: the changing role of rural financial institutions in China.

Brandt, L. and Zhu, X. (2000). Redistribution in a decentralized economy: growth and inflation in China under reform. *Journal of Political Economy*, 108(2):422–439.

Brandt, L. and Zhu, X. (2010). Accounting for China's growth.

Bulte, E., Heerink, N., and Zhang, X. (2011). China's one-child policy and 'the mystery of missing women': Ethnic minorities and male-biased sex ratios. *Oxford Bulletin of Economics and Statistics*, 73(1):21–39.

Burki, S. J. (1969). A study of Chinese communes 1965. *A study of Chinese communes 1965*.

Bustos, P., Caprettini, B., and Ponticelli, J. (2014). Agricultural productivity and structural transformation. evidence from Brazil. *Mimeo*.

Byrd, W. A. and Lin, Q. (1990). *China's rural industry: Structure, development, and reform*. Oxford University Press.

Cameron, A. C., Gelbach, J. B., and Miller, D. L. (2008). Bootstrap-based improvements for inference with clustered errors. *The Review of Economics and Statistics*, 90(3):414–427.

Cameron, A. C., Gelbach, J. B., and Miller, D. L. (2011). Robust inference with multiway clustering. *Journal of Business & Economic Statistics*, 29(2).

Carroll, C. D. and Weil, D. N. (1994). Saving and growth: a reinterpretation. In *Carnegie-Rochester Conference Series on Public Policy*, volume 40, pages 133–192. Elsevier.

Caselli, F. (2005). Accounting for cross-country income differences. *Handbook of economic growth*, 1:679–741.

Caselli, F. and Michaels, G. (2013). Do oil windfalls improve living standards? evidence from Brazil. *American Economic Journal: Applied Economics*, (5(1)):208–238.

Chan, K. W. (2001). Recent migration in china: Patterns, trends, and policies. *Asian perspective*, pages 127–155.

Chan, K. W. (2007). Misconceptions and complexities in the study of china's cities: Definitions, statistics, and implications. *Eurasian Geography and Economics*, 48(4):383–412.

Chan, K. W. and Zhang, L. (1999). The hukou system and rural-urban migration in China: Processes and changes. *China Quarterly*, pages 818–855.

Chang, C.-F., Lee, C.-F., McKibben, S. L., Poston, D. L., and Walther, C. S. (2005). *Fertility, family planning and population policy in China*. Routledge.

Chen, Y. and Henderson, J. V. (2015). The bias towards politically connected cities in China's capital markets.

Chen, Y., Li, H., and Meng, L. (2013). Prenatal sex selection and missing girls in China: Evidence from the diffusion of diagnostic ultrasound. *Journal of Human Resources*, 48(1):36–70.

Cheng, T. and Selden, M. (1994). The origins and social consequences of China's hukou system. *The China Quarterly*, 139:644–668.

Collins, S. M. and Bosworth, B. P. (1996). Economic growth in East Asia: accumulation versus assimilation. *Brookings Papers on Economic Activity*, pages 135–203.

Combes, P.-P., Démurger, S., Li, S., et al. (2013). Urbanisation and migration externalities in China. *Mimeo*.

Conley, T. G. (1999). GMM estimation with cross sectional dependence. *Journal of Econometrics*, 92(1):1–45.

Corden, W. M. and Neary, J. P. (1982). Booming sector and de-industrialisation in a small open economy. *The Economic Journal*, pages 825–848.

Costinot, A. and Donaldson, D. (2014). How large are the gains from economic integration? theory and evidence from us agriculture, 1880-2002. *Mimeo*.

Das Gupta, M. and Mari Bhat, P. (1997). Fertility decline and increased manifestation of sex bias in India. *Population Studies*, 51(3):307–315.

Das Gupta, M. and Shuzhuo, L. (1999). Gender bias in China, South Korea and India 1920–1990: Effects of war, famine and fertility decline. *Development and Change*, 30(3):619–652.

De Brauw, A., Huang, J., Rozelle, S., Zhang, L., and Zhang, Y. (2002). The evolution of China's rural labor markets during the reforms. *Journal of Comparative Economics*, 30(2):329–353.

Dekle, R. (1996). Saving-investment associations and capital mobility on the evidence from japanese regional data. *Journal of International Economics*, 41(1):53–72.

Deng, X., Huang, J., Rozelle, S., and Uchida, E. (2008). Growth, population and industrialization, and urban land expansion of china. *Journal of Urban Economics*, 63(1):96–115.

Deng, X., Huang, J., Rozelle, S., and Uchida, E. (2010). Economic growth and the expansion of urban land in china. *Urban Studies*, 47(4):813–843.

Desmet, K. and Rossi-Hansberg, E. (2013). Urban accounting and welfare. *The American Economic Review*, 103(6):2296–2327.

Dollar, D. and Wei, S.-J. (2007). Das (wasted) kapital: firm ownership and investment efficiency in China.

Dore, R. (1959). Land reform in Japan.

Easterly, W. and Levine, R. (2001). What have we learned from a decade of empirical research on growth? It's not factor accumulation: Stylized facts and growth models. *World Bank Economic Review*, 15(2):177–219.

Ebenstein, A. (2010). The missing girls of China and the unintended consequences of the one child policy. *Journal of Human Resources*, 45(1):87–115.

Ebenstein, A. (2014). Patrilocality and missing women. *Available at SSRN 2422090*.

Ebenstein, A. and Leung, S. (2010). Son preference and access to social insurance: evidence from China's rural pension program. *Population and Development Review*, 36(1):47–70.

Ebenstein, A. Y. (2007). Fertility choices and sex selection in Asia: Analysis and policy. *Available at SSRN 965551*.

Echevarria, C. (1997). Changes in sectoral composition associated with economic growth. *International Economic Review*, pages 431–452.

Fajgelbaum, P. and Redding, S. J. (2014). External integration, structural transformation and economic development: Evidence from Argentina 1870-1914. Technical report, National Bureau of Economic Research.

Feldstein, M. and Horioka, C. (1980). Domestic saving and international capital flows. *The Economic Journal*, 90(358):314–329.

Fischer, G., Nachtergaele, F., Prieler, S., Teixeira, E., Tóth, G., van Velthuizen, H., Verelst, L., and Wiberg, D. (2012). Global agro-ecological zones (gaez v3. 0)–model documentation. *International*

Institute for Applied systems Analysis (IIASA), Laxenburg. Rome, Italy: Austria and the Food and Agriculture Organization of the United Nations (FAO).

Fischer, S. (1994). Structural factors in the economic reforms of China, Eastern Europe, and the former Soviet Union. *Economic Policy*, pages 131–135.

Foster, A. D. and Rosenzweig, M. R. (2004). Agricultural productivity growth, rural economic diversity, and economic reforms: India, 1970–2000*. *Economic Development and Cultural Change*, 52(3):509–542.

Gollin, D., Jedwab, R., and Vollrath, D. (2013). Urbanization with and without industrialization. *Unpublished manuscript, Oxford University Department of International Development*.

Gollin, D., Parente, S. L., and Rogerson, R. (2007). The food problem and the evolution of international income levels. *Journal of Monetary Economics*, 54(4):1230–1255.

Harris, J. R. and Todaro, M. P. (1970). Migration, unemployment and development: a two-sector analysis. *The American Economic Review*, pages 126–142.

Heckman, J. J. and Walker, J. R. (1990). The relationship between wages and income and the timing and spacing of births: evidence from swedish longitudinal data. *Econometrica*, pages 1411–1441.

Helliwell, J. F. and McKitrick, R. (1999). Comparing capital mobility across provincial and national borders. *Canadian Journal of Economics*, pages 1164–1173.

Holz, C. A. (2014). The quality of china's gdp statistics. *China Economic Review*, 30:309–338.

Hornbeck, R. and Keskin, P. (2015). Does agriculture generate local economic spillovers? short-run and long-run evidence from the ogallala aquifer. *American Economic Journal: Economic Policy*, 7(2):192–213.

Huang, J. and Rozelle, S. (1996). Technological change: Rediscovering the engine of productivity growth in China's rural economy. *Journal of Development Economics*, 49(2):337–369.

Huang, Q., Rozelle, S., Lohmar, B., Huang, J., and Wang, J. (2006). Irrigation, agricultural performance and poverty reduction in China. *Food Policy*, 31(1):30–52.

Huang, Y. (1998). *Agricultural Reform in China*. Cambridge University Press.

Huang, Y. (2003). *Selling China: Foreign direct investment during the reform era*. Cambridge University Press.

Huang, Y. (2008). *Capitalism with Chinese characteristics: Entrepreneurship and the state*, volume 1. Cambridge UniversityPress.

Iwamoto, Y. and Van Wincoop, E. (2000). Do borders matter? evidence from japanese regional net capital flows. *International Economic Review*, 41(1):241–290.

Jayachandran, S. (2014). Fertility decline and missing women. *Mimeo*.

Jedwab, R. (2013). Urbanization without structural transformation: Evidence from consumption cities in africa. *George Washington University, Washington, DC. Processed*.

Jeon, Y.-D. and Kim, Y.-Y. (2000). Land reform, income redistribution, and agricultural production in korea. *Economic Development and Cultural Change*, 48(2):253–268.

Karabarbounis, L. and Neiman, B. (2014). The global decline of the labor share. *The Quarterly Journal of Economics*, 129(1):61–103.

Kim, J.-I. and Lau, L. J. (1994). The sources of economic growth of the east asian newly industrialized countries. *Journal of the Japanese and International Economies*, 8(3):235–271.

Kongsamut, P., Rebelo, S., and Xie, D. (1997). Beyond balanced growth. *NBER Working Paper 6159 (later ReStud, 2001)*.

Kongsamut, P., Rebelo, S., and Xie, D. (2001). Beyond balanced growth. *The Review of Economic Studies*, 68(4):869–882.

Lardy, N. R. (1983). *Agriculture in China's modern economic development*. Cambridge University Press.

Lardy, N. R. (1998). *China's unfinished economic revolution*. Brookings Institution Press.

Lewis, W. A. (1954). Economic development with unlimited supplies of labour. *The Manchester School*, 22(2):139–191.

Lin, J. Y. (1992). Rural reforms and agricultural growth in China. *The American Economic Review*, pages 34–51.

Lin, J. Y. and James, G. W. (1995). China's regional grain self-sufficiency policy and its effect on land productivity. *Journal of Comparative Economics*, 21(2):187–206.

Lin, M.-J., Qian, N., and Liu, J.-T. (2014). More women missing, fewer girls dying: The impact of abortion on sex ratios at birth and excess female mortality in and excess female mortality in taiwan. *Journal of the European Economic Association*, 12.

Matsuyama, K. (1992). Agricultural productivity, comparative advantage, and economic growth. *Journal of Economic Theory*, 58(2):317–334.

World Bank (2007). *World development report 2008: Agriculture for development*. World Bank.

McMillan, J., Whalley, J., and Zhu, L. (1989). The impact of China's economic reforms on agricultural productivity growth. *The Journal of Political Economy*, pages 781–807.

Michaels, G., Rauch, F., and Redding, S. J. (2012). Urbanization and structural transformation. *The Quarterly Journal of Economics*, 127:535–586.

Murphy, K. M., Shleifer, A., and Vishny, R. W. (1989). Income distribution, market size, and industrialization. *The Quarterly Journal of Economics*, 104(3):537–64.

Naughton, B. (1988). The Third Front: defence industrialization in the Chinese interior. *The China Quarterly*, 115:351–386.

Naughton, B. (1996). *Growing out of the plan: Chinese economic reform, 1978-1993*. Cambridge university press.

Naughton, B. (2007). *The Chinese economy: Transitions and growth*. MIT press.

Ngai, L. R. and Pissarides, C. A. (2007). Structural change in a multisector model of growth. *The American Economic Review*, 97(1):429–443.

Nunn, N. and Puga, D. (2012). Ruggedness: The blessing of bad geography in africa. *Review of Economics and Statistics*, 94(1):20–36.

Nunn, N. and Qian, N. (2011). The potato's contribution to population and urbanization: Evidence from a historical experiment. *The Quarterly Journal of Economics*, 126(2):593–650.

Oi, J. C. (1991). *State and peasant in contemporary China: The political economy of village government*, volume 30. University of California Press.

Oi, J. C. (1999). *Rural China takes off: Institutional foundations of economic reform*. Universityof California Press.

Park, A. and Sehrt, K. (2001). Tests of financial intermediation and banking reform in China. *Journal of Comparative Economics*, 29(4):608–644.

Park, C. B. and Cho, N.-H. (1995). Consequences of son preference in a low-fertility society: imbalance of the sex ratio at birth in Korea. *Population and Development Review*, pages 59–84.

Paweenawat, A. and Townsend, R. M. (2009). Villages as small open economies. *Work. Pap., Univ. Chicago*.

Perkins, D. H. (1988). Reforming China's economic system. *Journal of Economic Literature*, 26(2):601–645.

Pingali, P. L. and Xuan, V.-T. (1992). Vietnam: Decollectivization and rice productivity growth. *Economic Development and Cultural Change*, pages 697–718.

Poncet, S. (2003). Measuring Chinese domestic and international integration. *China Economic Review*, 14(1):1–21.

Qian, N. (2008). Missing women and the price of tea in China: The effect of sex-specific earnings on sex imbalance. *The Quarterly Journal of Economics*, 123(3):1251–1285.

Rosenstein-Rodan, P. N. (1943). Problems of industrialisation of Eastern and South-eastern Europe. *The Economic Journal*, 53(210/211):202–211.

Rosenzweig, M. R. and Schultz, T. P. (1982). Market opportunities, genetic endowments, and intrafamily resource distribution: Child survival in rural india. *The American Economic Review*, pages 803–815.

Rostow, W. W. (1960). *The stages of economic growth: A non-communist manifesto*. Cambridge University Press.

Scharping, T. (2013). *Birth Control in China 1949-2000: Population policy and demographic development*. Routledge.

Schultz, T. W. (1953). *The economic organization of agriculture*. McGraw-Hill New York.

Sen, A. (1990). More than 100 million women are missing. *The New York Review of Books*.

Sen, A. (1992). Missing women. *BMJ: British Medical Journal*, 304(6827):587.

Sicular, T. (1988). Agricultural planning and pricing in the post-Mao period. *The China Quarterly*, 116(1):671–705.

Sinn, S. (1992). Saving-investment correlations and capital mobility: On the evidence from annual data. *The Economic Journal*, pages 1162–1170.

Song, Z., Storesletten, K., and Zilibotti, F. (2011). Growing like China. *The American Economic Review*, 101(1):196–233.

Taylor, J. E., Rozelle, S., and De Brauw, A. (2003). Migration and incomes in source communities: A new economics of migration perspective from china*. *Economic Development and Cultural Change*, 52(1):75–101.

Taylor, J. R. (1988). Rural employment trends and the legacy of surplus labour, 1978-86. *The China Quarterly*, 116:736–66.

Thorbecke, E. (1979). Agricultural development. *Economic Growth and Structural Change in Taiwan: The Postwar Experience of the Republic of China*, pages 132–205.

University of Michigan China Data Center (2006). Historical China county population census data with GIS maps.

Wang, J. (2012). The economic impact of special economic zones: Evidence from Chinese municipalities. *Journal of Development Economics*.

Wang, X. and Herd, R. (2013). The system of revenue sharing and fiscal transfers in China.

White, T. (2006). *China's longest campaign: birth planning in the People's Republic, 1949-2005*. Cornell University Press.

Willis, R. J. (1973). A new approach to the economic theory of fertility behavior. *The Journal of Political Economy*, pages S14–S64.

Yi, Z., Ping, T., Baochang, G., Yi, X., Bohua, L., and Yongpiing, L. (1993). Causes and implications of the recent increase in the reported sex ratio at birth in China. *Population and Development Review*, pages 283–302.

Young, A. (1995). The tyranny of numbers: confronting the statistical realities of the East Asian growth experience. *The Quarterly Journal of Economics*, 110(3):641–680.

Young, A. (2000). The razor's edge: distortions and incremental reform in the People's Republic of China. *The Quarterly Journal of Economics*, 115(4):1091–1135.

Young, A. (2003). Gold into base metals: Productivity growth in the People's Republic of China during the reform period. *Journal of Political Economy*, 111(6):1220–1261.

Appendices

Appendix A

Appendices to Chapter 1: The Agricultural Roots of Industrial Development: 'Forward Linkages' in Reform era China

A.1 Proofs of Comparative Statics

Proof of Comparative Statics 1: Baseline. As capital is mobile there are no transition dynamics for any variables other than savings. All other variables adjust immediately to their steady state values. Constant returns to scale imply that the unit cost function of the non-agricultural sector is of the form $c^N(w_t, r_t)$. Competition implies that $c^N(w_t, r_t) = p_t^N$. As the economy is open to trade in goods and capital flows $r_t = \tilde{r}$, $p_t^N = \tilde{p}\ \forall\, t$ then $w_t = \bar{w}\ \forall\, t$. Shephard's Lemma implies that $L^N = y^N c_1^N(\bar{w}, \tilde{r})$, the output of the non-agricultural sector is linear in the supply of labour and by the same argument so is capital. A non-labour saving increase in agricultural productivity increases the marginal product of labour in the agricultural sector for a given labour allocation. As land is fixed, L_{ss}^A must increase to equalise the marginal product of labour with the wage. Thus, agricultural output increases, the share of labour in the agricultural sector increase and non-agricultural output and capital decrease. By Envelope Theorem $Y_t = p^A y A_t + p^N y N_t$ is also increasing in productivity. At the steady state $S_t = S_{t+1}$ so rearranging Equation 1.1 provides $S_{ss} = \frac{s(Y_{ss} - (\tilde{r}+\delta)K_{ss})}{1-s(1+\tilde{r})}$ as output increases and capital decreases, steady state savings must also increase. □

Proof of Comparative Statics 2: Labour Channel. The proof is largely as for the baseline comparative statics. However, a labour saving increase in Ψ_q decreases the marginal product of labour in agriculture for a given labour allocation. As land is fixed, L_{ss}^A must increase until $MPL_t^A = \bar{w}$. Thus L^N, y^N and K^N increase. By Envelope Theorem $Y_{ss} - (\tilde{r} + \delta)K_{ss}$ increases, so steady state savings must also increase. □

Proof of Comparative Statics 3: Capital Channel. With local capital market clearing imposed (Equation 1.8) the savings accumulation Equation 1.1 becomes capital accumulation condition

$$K_{t+1}(K_t) = s(Y_t(K_t) + (1-\delta)K_t) \tag{A.1}$$

The supply of labour and land are fixed so output, $Y_t(K_t)$, is an increasing function of K_t. The agricultural sector uses only land and labour, so

$Y(0) > 0$. I have assumed that f^N is strictly concave and that the marginal product of capital converges to 0 as $K \to \infty$, so in the limit Y_t does not increase in K. As $s(1-\delta) < 1$ there is a steady state K_{ss} such that $K_{t+1} > K_t$ for all $K_t < K_{ss}$ and $K_{t+1} < K_t$ for all $K_t > K_{ss}$. Consequently, there is a unique stable steady state where $K_{ss} = \frac{sY_{ss}}{1-s(1-\delta)}$.

The economy is a sequence of static equilibria. Using the labour market clearing condition, output in the economy is

$$Y_t = \max_{L_t^N} \tilde{p}^A \Psi_H f^A(\Psi_L(L - L_t^N),\, \Psi_B B_t) + \tilde{p}^N f^N(L_t^N,\, K_t) \tag{A.2}$$

plugging the solution L_t^N back in and applying envelope theorem we obtain $\frac{\partial Y_t}{\partial \Psi_q} > 0$. Output is increasing in agricultural productivity for any K_t. Combined with Equation A.1, this implies that K_{ss} is also increasing in Ψ_q.

Total differentiation of the first order conditions of the maximisation problem provide conditions for L_{ss}^N to be increasing in labour augmenting land, augmenting and Hicks-Neutral increases in agricultural technology

$$p_A \Psi_H f_1^A \left(1 + \Psi_L(1 - L_N)\, f_{11}^A\right) - p_N f_1^N f_{12}^N \frac{\partial K_{ss}}{\partial \Psi_L} < 0 \tag{A.3}$$

$$p_A \Psi_H \Psi_L f_{12}^A - p_N f_1^N f_{12}^N \frac{\partial K_{ss}}{\partial \Psi_B} < 0 \tag{A.4}$$

$$p_A \Psi_L f_1^A - p_N f_1^N f_{12}^N \frac{\partial K_{ss}}{\partial \Psi_B} < 0 \tag{A.5}$$

whether each inequality holds depends on f^A and f^N. When agricultural technology is not labour saving there are two effects: higher agricultural technology increases the returns to agriculture but higher savings draws labour into the non-agricultural sector, the effect on the labour force is the net of these two forces.

Changes in non-agricultural output can be decomposed as $\frac{d}{d\Psi_q} y_N = \frac{\partial y_N}{\partial L} \frac{\partial L}{\partial \Psi_q} + \frac{\partial y_N l}{\partial K} \frac{\partial K}{\partial \Psi_q}$. The second part is always positive, so non-agricultural output increases if the demand for labour in the agricultural sector doesn't increase too much.

Holding factors constant, the marginal product of labour in both sectors has increased. Hence the wage increases. Because the non-agricultural sector is competitive and has constant returns to scale in equilibrium $c^N(w_t, r_t) = p_t^N$. Prices are fixed and costs are increasing in both factors so the rental rate r on capital must fall.

□

Proof of Comparative Statics 4: Demand Channel. As capital is mobile there are again no dynamics for other than for the stock of savings. In any equilibrium

$$\eta^A y_t^A = \eta^N y_t^N \tag{A.6}$$

Holding all factor allocations constant, an increase in Ψ_q increases the output of the agricultural sector but has no effect on non-agricultural output. As y_t^A and y_t^N are both strictly and continuously increasing in L it is feasible to reduce L_t^A and increase the output of the non-agricultural sector and the overall level of output. Both y_t^A and y_t^N must increase.

The final good is the numeraire so competition in the final goods market implies that

$$p^F = \frac{p_t^A}{\eta^A} + \frac{p_t^N}{\eta^N} = 1 \tag{A.7}$$

holding p_t^A and p_t^N constant, an increase in Ψ_q increases the output of the agricultural sector and decreases that of the non-agricultural sector (as in the baseline comparative statics). However, in equilibrium the output of both sectors increases. As both sectors output are increasing in their own price, p_t^j, the relative price of non-agricultural output must increase.

Competition in the non agricultural sector implies $c^N(w_t, \tilde{r}) = p_t^N$. As capital mobility fixes $\tilde{r}$ the wage must increase. By Shephard's Lemma, $K_t^N = y_t^N \frac{\partial c^N(w_t, \tilde{r})}{\partial \tilde{r}}$ so

$$\frac{\partial K_t^N}{\partial \Psi_q} = \frac{\partial y_t^N}{\partial \Psi_q} \frac{\partial c^N(w_t, \tilde{r})}{\partial \tilde{r}} + y_t^N \frac{\partial^2 c^N(w_t, \tilde{r})}{\partial \tilde{r} \partial w_t} \frac{\partial w_t}{\partial \Psi_q} \tag{A.8}$$

which is > 0 as all terms are positive; capital utilised increases. A similar expression can be obtained for labour, but the overall effect depends on whether the increase due to higher productivity is offset by the reduction due to the wage. □

A.2 Additional Data Sources

A.2.1 Province level data

Province level Primary GDP data for the provincial level regressions was obtained from the University of Michigan Data Center for all years between 1949-2011 and for all provinces other than Hong Kong and Macau. Provincial level suitability for cash crops is calculated in an almost identical fashion to that which I calculate county-level suitability i.e. I take the simple average of suitability for cash crops for each cell in the province. One minor difference is that instead of normalising by the standard deviation of provincial suitability (0.3) I use the county level standard deviation (0.4). This ensures that the coefficients refer to the same absolute change in suitability and are thus directly comparable. Normalising by the provincial level suitability would reduce the absolute size of my estimated coefficients in table 1.6 columns 4-7.

A.2.2 County level census data

Geocoded county level census data for 1982, 1990 and 2000 were obtained from the University of Michigan China Data Center for all counties outside Hong Kong, Macao and Tibet. Because boundaries of some counties change over time, I took the following steps to link the counties. First, I calculated the centroids for all counties in all years. Second, for each year, I count the number of centroids contained within a counties polygon for each of the other years. I then discard all counties where this number is not equal to one for both years. I then merge the three datasets together and drop all counties for which data do not exist for

all three years. This eliminates counties which were split or merged as well as counties with large border changes, however some minor border may changes may remain. The remaining number of counties is 2142 (compared to 2310 in 1982, more in later censuses). The same procedure is used to link the education data in the 1982 census to the 1999 borders I use for my main data set (33 of 561 counties dropped).

A.2.3 Geographic data on 'openness' (proximity to historic cities and airports)

Distance to nearest Historic City and nearest International airport was defined for each county as the distance from the county centroid to the centroid of nearest the Historic City or International Airport. The distances were calculated using the Python *geopy* package and the *distance* module. This calculates the distance between points based on the Vincenty formula which assumes the earth is an Oblate Spheroid and so allows for the curvature of the earth. To the extent to which travel time differs from geogrpahic distance this will introduce some error. Unfortunately, I am not aware of good maps of China's transport network for the cultural revolution era and calculating travel times based on present day transport networks is undesirable for obvious reasons. The set of historic cities in section 1.6.3 are the set historical cities used by Banerjee et al. (2012) and the full set of treaty ports. These are Beijing, Tianjin, Qinhuangdao, Taiyuan, Manzhouli, Shengyang, Luda, Niuzhuang, Changchun, Jilin, Hunchun, Harbin, Qiqihar, Suifenhe, Aihui, Shanghai, Nanjing, Suzhou, Dongha, Zhenjiang, Hangzhou, Ningbo, Wenzhou, Wuhu, Fuzhou, Xiamen, Sanduao, Nanchang, Chiujiang, Jinan, Qingdao, Yantai, Weihai, Hankou, Yichang, Shashi, Changsha, Yueyang, Changde, Guangzhou, Shantou, Sanshui, Nanning, Wuzhou, Beihai, Longzhou, Qiongshan, Chongqing, Chengdu, Guiyang, Kunming, Tengchong, Simao, Mengzi, Xian and Lanzhou. I believe this list of Cities was originally compiled by Banerjee et al. The location of international

airports was obtained from the ACASIAN Data Centre's map of Chinese International Airports in 2007.

A.2.4 Climatic data

Data on average annual precipitation (mm) and mean annual temperature (°C) between 1961 and 1990 were obtained from the FAO's GAEZ database. Counties were assigned the temperature and precipitation equal to the mean temperature and precipitation of all grid cells within the county.

A.2.5 Firm level data

Firm level data was obtained from the Third Industrial Census (1995). This data contains detailed micro-data for more than 510,000 medium and large enterprises—all firms with independent accounting systems. These firms account for 85% of the value of industrial output and encompass the vast majority of state owned enterprises, but will provide less complete coverage of non-state firms which tend to be smaller. The data contain information on a wide number of variables including the founding date, location and the ownership type of firms as well as profits, wages paid and capital used. I use the county the firms are located in to link them with my data on county level suitability for cash crops. I exclude firms from Tibet, Macao, Hong Kong as well as firms in cities whose metropolitan areas cover more than one county level administrative unit (about 200 county level administrative units). I also exclude firms with obvious reporting errors.[1] Table 1.2, panel B summarises some of this data.

[1] I drop firms that are missing their start dates, firms whose total gross assets are less than their fixed assets, firms missing an ID and firms without strictly positive sales.

A.3 Robustness Checks

A.3.1 Alternative fixed effect specifications

My main results are estimated using a specification including county and province-by-time fixed effects. This specification means that I am only working off within-province variation. The results are, however, robust to the choice of fixed effects. Table A.1 re-estimates the reduced form results for agricultural and non-agricultural output using increasingly demanding fixed effect specifications.

In Column 1, I estimate

$$Y_{ivt} = \alpha + \delta_t + \beta_0 SCC_i^N + \beta_1 (SCC_i^N \times D1985_t) + \beta_2 (SCC_i^N \times Post85_t) + \varepsilon_{ivt} \tag{A.9}$$

this specification does not include county fixed effects, so SCC_i^N must be included directly to allow for pre-existing differences in suitability. This specification also includes only time-fixed effects. Panel A provides results for the agricultural sector, B the non-agricultural sector. For both sectors the coefficients on the interaction terms are similar to my baseline results, although a modest effect on non-agricultural output is now perhaps apparent by 1985. The pre-reform correlation between suitability and agricultural and non-agricultural output indicated by the coefficient on suitability is minimal.

In Column 2, I add county fixed effects and estimate

$$Y_{ivt} = \alpha_i + \delta_t + \beta_1 (SCC_i^N \times D1985_t) + \beta_2 (SCC_i^N \times Post85_t) + \varepsilon_{ivt} \tag{A.10}$$

the results are very similar to my baseline results (restated in Column 3) although a modest effect on non-agricultural output is now perhaps apparent by 1985.

In Column 3, I provide my baseline results (Equation 1.10), estimated using province-by-time fixed effects. The similarity of my baseline results to those obtained using a less demanding specification are reassuring as they indicate that any unobserved confounder ought to be correlated with

Table A.1: Robustness of Results to Alternative FE Specifications

			Baseline	
	(1)	(2)	(3)	(4)
A. Ln Primary GDP				
Suitability for Cash Crops × 1985	0.137	0.151***	0.162***	0.087
	(0.110)	(0.037)	(0.056)	(0.101)
Suitability for Cash Crops Crops × Post 1985	0.217***	0.232***	0.236***	0.229*
	(0.066)	(0.033)	(0.068)	(0.117)
Suitability for Cash Crops	-0.002			
	(0.080)			
Observations	8000	8000	8000	8000
Counties	561	561	561	561
B. Ln Non-Agricultural GDP				
Suitability for Cash Crops × 1985	0.081	0.099*	0.022	-0.014
	(0.110)	(0.055)	(0.031)	(0.074)
Suitability for Cash Crops × Post 1985	0.225***	0.245***	0.181**	0.032
	(0.082)	(0.066)	(0.072)	(0.089)
Suitability for Cash Crops	0.044			
	(0.081)			
Observations	7993	7993	7993	7993
Counties	561	561	561	561
County FE		Yes	Yes	Yes
Year FE	Yes	Yes		
Province x Year FE			Yes	
Prefecture x Year FE				Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985, years after 1985, or years after 1978. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

suitability for cash crops in the same way across provinces as it is between provinces.

In Column 4, I include the results of a specification including very demanding prefecture-by-time fixed effects. The prefecture is the administrative unit between the county and the province, on average a prefecture contains 7-8 counties (and a province contains an average of 10 prefectures). This means that we are exploiting variation only between immediate neighbors—because suitability for cash crops is spatially correlated, only 12% of the variation in suitability exists within prefectures. Because counties are not perfectly closed, the existence of spillovers between neighbouring counties may limit our ability to identify the effect of specialisation and linkages from agriculture.

For agricultural output, the confounding effect of spillovers appears minimal. The estimated coefficients in this specification are once again similar to my baseline results. This is consistent with a world where the primary determinant of how profitable planting cash crops is (relative to planting grain) is how productive your land is; a plausible scenario.

Unlike the results for agricultural output, the non-agricultural results are not robust to the inclusion of prefecture-by-time fixed effects. Given the nature of the linkages, this is not surprising. My results indicate that the increase in non-agricultural output is driven by an increase in the supply of local capital. While there are geographic frictions in local capital markets, they are not perfect at the county level. In particular, rural credit cooperatives, the most important destination for rural savings and an important source of loans for rural non-state firms may operate across county lines. Because of this, the effect on non-agricultural output is likely to extend beyond the immediate county and to it's neighbours. Spillovers to agricultural output are likely to be much more limited. The results of (unreported) Spatial-Durbin Panel estimates support this intuition; spillovers are much stronger for non-agricultural output.

A.3.2 Geographic factors

Although there is considerable heterogeneity in suitability for cash crops across China, it is possible that agricultural productivities are correlated with some other factors that also became increasingly advantageous in the reform era. In this section I explore two possible factors that could potentially be doing just that: absolute productivity and ruggedness of terrain.

While suitability for cash crops is a natural measure of the availability of gains from specialisation in cash crops it is, by construction, correlated with the absolute productivity of grain and cash crops. It is possible that it is these that were important subsequent to reform. For instance, in appendix section I showed that high absolute productivity in cash crops strongly influenced the location of cash crop processing facilities. If the processing of cash crops was particularly valuable, for instance due to strong learning by doing, this may have translated into long term advantage. Table A.2 provides results of regressions with controls for time varying effects of absolute productivities of grains and cash crops. My main results are almost unchanged, and absolute advantage in either grain or cash crops has no statistically significant time varying effect on either agricultural or non-agricultural output.

In the pre-reform era, the Chinese economy was heavily planned, thus placement of industry was not always driven by economic considerations. For instance, the 'Third Front' program encouraged the development of industrial capacity in mountainess interior regions of China for national security reasons (Naughton, 1988). In the reform era, the market had an increasing role. In general, more rugged terrain is unfavourable for economic activity (see e.g. Nunn and Puga 2012). It makes the transportation of goods more challenging and increases building costs. It also has a direct effect on agricultural productivity and is one of the inputs to the GAEZ data that use to construct my measure of suitability to cash crops. It is possible that ruggedness is more unfavourable for cash crops than grains, and thus that the effect of cash crops on subsequent

Table A.2: Geographic Conditions

	Ln Primary GDP					*Ln Non-Ag GDP*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Suitability for Cash Crops × 1985	0.164**	0.168***	0.170**	0.249***	0.157***	-0.038	0.052	0.074	0.120*	0.006
	(0.071)	(0.059)	(0.067)	(0.074)	(0.056)	(0.046)	(0.041)	(0.052)	(0.067)	(0.039)
Suitability for Cash Crops × Post 1985	0.167*	0.216***	0.198**	0.288***	0.226***	0.154*	0.205**	0.218**	0.246**	0.168**
	(0.087)	(0.080)	(0.093)	(0.111)	(0.070)	(0.086)	(0.082)	(0.097)	(0.111)	(0.081)
Share of Low Gradient Land × 1985	0.093					0.121				
	(0.143)					(0.111)				
Share of Low Gradient Land × Post 1985	0.171					-0.043				
	(0.163)					(0.210)				
Share of High Gradient Land × 1985	0.079					-0.063				
	(0.135)					(0.064)				
Share of High Gradient Land × Post 1985	-0.048					-0.130				
	(0.110)					(0.145)				
Ln Value of Best Grain × 1985		-0.023					-0.092			
		(0.071)					(0.057)			
Ln Value of Best Grain × Post 1985		0.061					-0.075			
		(0.064)					(0.090)			
Ln Value of Best non-Grain × 1985			-0.016					-0.080		
			(0.069)					(0.053)		
Ln Value of Best non-Grain × Post 1985			0.058					-0.057		
			(0.056)					(0.082)		
Average Annual Temperature 1961-1990 °C× 1985				-0.026***					-0.029*	
				(0.008)					(0.017)	
Average Annual Temperature 1961-1990 °C× Post 1985				-0.016					-0.020	
				(0.018)					(0.027)	
Average Annual Rainfall 1961-1990 (mm) × 1985					-0.000					-0.000
					(0.000)					(0.000)
Average Annual Rainfall 1961-1990 (mm) × Post 1985					-0.000					-0.000
					(0.000)					(0.000)
Observations	8000	8000	8000	8000	8000	7993	7993	7993	7993	7993
Counties	561	561	561	561	561	561	561	561	561	561
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

productivity is simply coming through the increased benefit of low transport and construction costs. To check for this, I calculate the share of land that is 'Low Gradient' or 'High Gradient' in each county using the GAEZ data on gradient. A cell is defined as flat, if its median gradient lies in the bottom three categories (less than 5°), and hilly if its median gradient lies in one of the top three categories (more than 16°). Share of terrain betwen 5° and 16° is the ommitted category. Table A.2 includes the results of regressions using these additional controls interacted with year. The coefficients on terrain gradient are insignificant and not of consistent sign. The coefficients on my main results are somewhat less precisely estimated, but very similar to my baseline results an remain statistically significant at the 10% level.

Because suitability for cash crops is correlated with average temperature, I also allow for the possibility that temperature and, for completeness, precipitation levels are driving the differential subsequent growth (columns 4, 5 9 and 10). They are not. The estimated coefficients on suitability for cash crops are similar to my baseline estimates.

A.3.3 Initial conditions

If initial economic conditions were correlated with suitability for cash crops, I could be erroneously attributing the effect of more favourable initial economic conditions to the benefits of specialisation. In table A.3, I include interactions with initial GDP per capita, the share of agriculture in GDP and initial population density. My main results are unaffected, however the coefficients on the interactions with initial agricultural share of GDP are positive and significant. As China experienced a large increase in agricultural productivity across the board, these counties may also have had a disproportionate increase in the supply of capital to the non-agricultural sector.

In table A.4, I combine my data with two proxies for education from the 1982 population census: the literacy rate and the level of college enrollment. These capture current levels of basic education and the future

Table A.3: Initial Economic Conditions

	Ln Primary GDP			*Ln Non-Ag GDP*		
	(1)	(2)	(3)	(4)	(5)	(6)
Suitability for Cash Crops × 1985	0.170***	0.166***	0.173***	0.016	0.020	0.015
	(0.063)	(0.058)	(0.064)	(0.039)	(0.034)	(0.035)
Suitability for Cash Crops × Post 85	0.246***	0.231***	0.236***	0.196**	0.203***	0.180***
	(0.068)	(0.069)	(0.068)	(0.079)	(0.073)	(0.069)
Ln 1978 GDP per capita × 1985	-0.126**			-0.020		
	(0.057)			(0.103)		
Ln 1978 GDP per capita × Post 85	-0.133*			-0.196		
	(0.068)			(0.119)		
Ln 1978 Primary Share × 1985		0.065			0.079	
		(0.058)			(0.096)	
Ln 1978 Primary Share × Post 85		-0.083			0.327***	
		(0.058)			(0.104)	
Ln Population Density × 1985			-0.036			-0.002
			(0.023)			(0.023)
Ln Population Density × Post 85			-0.000			0.003
			(0.025)			(0.040)
Observations	7708	7749	7863	7701	7742	7856
Counties	535	538	549	535	538	549
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

supply of high skill workers. Because of boundary changes between 1982 and 1999, I am forced to drop 33 counties from my sample. For the remaining counties, controlling for 'initial' levels of eduction do not substantively change my main results. However, areas with higher initial levels of literacy did have faster non-agricultural output growth after the reforms.[2]

A.3.4 Access to markets

In the reform era, China has traded more with itself and more with the rest of the world. If my measure of suitability is correlated with closeness to major markets I may be picking up this, rather than the beneficial effects of higher agricultural output.

To proxy for a counties 'openness' I calculate the log crow flies distance from each counties centroid to the nearest point in one of two proxies for major cities. The first proxy is the location of International Airports in 2007. As many airports have been built since the end of the Cultural Revolution, their location is endogenous to our outcome of interest, as would be other contemporary measures of city size or importance. To mitigate this I follow Combes et al. (2013) and use the location of historic cities and treaty ports as my second proxy. These cities were all established by 1920 and their location is thus more plausibly exogenous.[3] I also present results using the location of treaty ports and historic cities as an instrument for modern day locations of International Airports.

Table A.5 contains the results of regressions with these additional controls. My main results remain unchanged. Counties further away from airports and historic cities did experience lower growth in non-agricultural output. No significant differential pattern exists for agricul-

[2]If I estimate coefficients on the 1982 levels of education for each year of the data (not-reported), the post-reform growth appears to be a continuation pre-reform trend (ignoring the clear endogeneity of 1982 education to pre 1982 growth). Counties with higher levels of literacy were in 1982 were growing faster before the reforms and continued to do so afterwards.

[3]Construction of this data is described in appendix A.2

Table A.4: Initial Education

	Ln Primary GDP		*Ln Non-Ag GDP*	
	(1)	(2)	(3)	(4)
Suitability for Cash Crops × 1985	0.150***	0.149***	0.015	0.026
	(0.056)	(0.058)	(0.031)	(0.039)
Suitability for Cash Crops × Post 85	0.225***	0.229***	0.178**	0.188**
	(0.069)	(0.069)	(0.072)	(0.077)
Ln(Literacy Rate in 1982) × 1985	-0.053		0.385***	
	(0.113)		(0.132)	
Ln(Literacy Rate in 1982) × Post 85	0.185		0.590***	
	(0.153)		(0.184)	
Ln(% Enrolled in College in 1982) × 1985		0.005		0.086
		(0.042)		(0.052)
Ln(% Enrolled in College in 1982) × Post 85		0.029		0.010
		(0.052)		(0.071)
Observations	7580	7580	7573	7573
Counties	528	528	528	528
County FE	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Educational outcomes from 1982 Population Census. Counties with significant border changes between 1982-1999. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

Table A.5: 'Openness' and Suitability for Cash Crops

	Ln Primary GDP			*Ln Non-Agricultural GDP*		
	(1) OLS	(2) OLS	(3) IV	(4) OLS	(5) OLS	(6) IV
Suitability for Cash Crops × 1985	0.167***	0.151***	0.176***	0.019	0.035	0.016
	(0.055)	(0.053)	(0.039)	(0.038)	(0.032)	(0.036)
Suitability for Cash Crops × Post 85	0.232***	0.236***	0.235***	0.171***	0.195***	0.173***
	(0.069)	(0.067)	(0.059)	(0.066)	(0.070)	(0.064)
Ln Distance to Nearest Airport × 1985	0.017		0.179*	-0.153**		-0.167*
	(0.074)		(0.095)	(0.068)		(0.092)
Ln Distance to Nearest Airport × Post 85	-0.079		-0.003	-0.234***		-0.191
	(0.073)		(0.083)	(0.072)		(0.124)
Ln Distance to Nearest Historical City × 1985		0.072			-0.075	
		(0.046)			(0.054)	
Ln Distance to Nearest Historical City × Post 85		-0.000			-0.085	
		(0.042)			(0.073)	
Observations	8000	8000	8000	7993	7993	7993
Counties	561	561	561	561	561	561
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes	Yes
First Stage *F*			7.38			7.38

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Time interaction terms are dummies for 1985 or years after 1985. Distance interactions are (demeaned) ln crow flies distance to nearest airport or nearest historic city. In column 3, distance to nearest international airport and the various interactions are instrumented for by distance to nearest historical city. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

tural output. Although these coefficients should not be considered causal the general pattern is reassuring.

A.3.5 Special Economic Zones

Wang (2012) shows that the creation of Special Economic Zones (SEZs) in China was followed by faster TFP growth and investment from abroad. SEZs are place based policies which typically provide a package of investment incentives and more liberal economic policies designed to encourage export-based manufacturing. Because of the geographic nature of of SEZs it is possible that their placement was correlated with a suitability for cash crops either by chance, or because areas suited to cash crops had already had some success in manufacturing. Either way, SEZs could be the true driver of some or all of the growth in non-agricultural output. To test this I use the the data from Wang (2012) to construct two measures of a county's exposure to special economic zones. The first, is the number of SEZs in the same prefecture as the county (in the previous year). The second is a dummy variable taking a value of one when there are one or more SEZs in the same prefecture (in the previous year). Table A.6 includes the results of regressions including these as additional controls—the main results are unchanged and there is no clear pattern of coefficients on my SEZ variables. Unfortunately I only have data on SEZs at the prefecture level, which introduces some measurement error in exposure to SEZs at the county level.

A.3.6 Calculation of relative productivities and trimming

Table A.7 reestimates my main results with suitability for cash crops calculated in a number of different possible ways.

Column 1 restates my main results. Column 2 substitutes 'rain-fed' GAEZ productivites for my preferred irrigated ones. The coefficients decline in magnitude but generally remain statistically significant. It is worth noting that China is one of the most heavily irrigated countries

Table A.6: Special Economic Zones

	Ln Primary GDP		*Ln Non-Ag GDP*	
	(1)	(2)	(3)	(4)
Suitability for Cash Crops × 1985	0.161***	0.162***	0.022	0.021
	(0.057)	(0.058)	(0.031)	(0.031)
Suitability for Cash Crops × Post 85	0.241***	0.240***	0.188***	0.186***
	(0.069)	(0.069)	(0.070)	(0.071)
Prefectural SEZ's (count)	0.003		0.007	
	(0.006)		(0.010)	
Prefectural SEZ's (dummy>0)		0.064		-0.021
		(0.068)		(0.082)
Observations	7449	7449	7444	7444
Counties	561	561	561	561
County FE	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Prefectural SEZ's (count) and (dummy) are respectively, the number of Special Economic Zones located in the same prefecture as the county and a dummy taking a value of 1 if there at least one Special Economic Zone in the same prefecture. Data on SEZ's obtained from Wang (2012). Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

in the world, and cash crops, wheat and rice are particularly widely irrigated. To whit, (Huang et al., 2006) finds that 95% of cotton area, 69% of peanut area, 95% of rice area and 61% wheat area are irrigated. The intensive use of irrigation in China makes the GAEZ rain-fed productivities relatively uninformative about Chinese agricultural productivities. It is thus not surprising that the estimated coefficients are severely attenuated. One illustration of this induced error is the fact that the use of rain-fed agricultural inputs results in 54 counties, principally in the desert areas of Xinjiang and Gansu, being classified as agriculturally unproductive due to lack of rain-fall. However, despite their unsuitability for rain fed agriculture, these counties do have substantial levels of agricultural production.[4]

Changes in input intensity or prices used to calculate suitability do not affect the results. Column 3 uses 'high input' productivities in place of the standard intermediate level of inputs. Columns 4 and 5 use intermediate inputs combined with 1978 below quota prices and 1985 above quota prices respectively. My results are not sensitive to these choices.

To rule out the possibility that the data is driven by outliers, I trim the 1% of largest outliers from the data by running a regression including only the fixed effects. I then drop the 1% of observations with the largest absolute errors and reestimate by baseline specification (column 6). My results do not change significantly, assuaging fears that the results are due to outliers.

If the GAEZ productivities were Hicks-Neutral productivity shifters, and the prices and productivities used to calculate suitability were the true ones faced by rural households, then it would only be profitable to switch if the relative productivity was in excess of 1 (i.e. $SCC > 1$). However, the GAEZ productivities are likely to deviate from the true productivities at the level of the cell, and even when the measured and true productivities coincide on average, there will be some variation in

[4]Note that the change in coefficients is not being driven by the exclusion of these counties; my baseline results are almost unchanged if they are reestimated excluding these counties but using irrigated agricultural productivities. Results not reported.

Table A.7: Different Prices, Productivities and Outliers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Price Year	1978	1978	1978	1978	1985	1978	See
Above or Below-Quota Prices	AQ	AQ	AQ	BQ	AQ	AQ	table
Irrigated or Rain Fed	IR	RF	IR	IR	IR	IR	notes
Intermediate or High Inputs	INT	INT	HI	INT	INT	INT	
Trimmed	-	-	-	-	-	99	-
A. Ln Agricultural GDP							
Suitability for Cash Crops × 1985	0.162***	0.017	0.151***	0.131***	0.139***	0.093*	0.163***
	(0.056)	(0.024)	(0.052)	(0.048)	(0.051)	(0.050)	(0.050)
Suitability for Cash Crops × Post 85	0.236***	0.064**	0.227***	0.201***	0.210***	0.172***	0.235***
	(0.068)	(0.033)	(0.063)	(0.060)	(0.063)	(0.066)	(0.067)
Observations	8000	7205	8000	8000	8000	7920	8000
B. Ln Non-Agricultural GDP							
Suitability for Cash Crops × 1985	0.022	0.014	0.022	0.018	0.020	0.022	0.032
	(0.031)	(0.035)	(0.030)	(0.030)	(0.031)	(0.030)	(0.032)
Suitability for Cash Crops × Post 85	0.181**	0.063*	0.172**	0.163**	0.170**	0.183***	0.172**
	(0.072)	(0.032)	(0.069)	(0.066)	(0.068)	(0.070)	(0.080)
Observations	7993	7198	7993	7993	7993	7912	7993
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008. Column 2 has data from fewer counties than the other columns as under rain-fed agriculture some counties are classified as entirely unproductive in the GAEZ data. It is worth noting that China is one of the most heavily irrigated countries in the world making the rain-fed agricultural productivity data particularly unsuitable for analysis of agriculture in China (see section A.3.6). In column 7, suitability for cash crops at the cell level initially calculated as $\max\{0, SCC_i - 1\}$ where SCC_i is as defined in equation 1.12 and as used in column 1. This captures the idea that under the interpretation of the GAEZ productivities as Hicks-Neutral productivity shifters, then in the absence of measurement error, profit maximising farmers gain from growing cash crops only if this ratio is in excess of 1. The county level measure takes the average of all cells within the county and divides by the standard deviation of my baseline measure of suitability to facilitate comparison with my other measures (which are also normalised).

true productivity within a cell. Consequently, my main specification assumes that the gains from specialisaing are increasing throughout the distribution of measured productivities (and not just above some cutoff). In figure 1.5, we observe agricultural output growth increasing roughly linearly in suitability throughout the distribution which suggests that this assumption was reasonable. Nevertheless, as a robustness check I allow for the possibility that there were only gains from growing cash crops in cells where the revenue from cash crops was measured as being greater than that for grain and for each cell calculate $SCCT_\iota = \max\{0, SCC_\iota - 1\}$ where SCC_ι is as defined in equation 1.12. To obtain a county level measure I take the simple average across all cells in the county. Then, for comparability with my baseline specification, I normalise by the standard deviation of my baseline measure of suitability. The results using this measure are in column 7 and are very similar to my baseline results.

A.3.7 Omission of any particular province

Table A.8 reestimates my main results omitting each province used in turn. This may be of particular interest for the Western provinces of Gansu and, especially, Xinjiang where a significant portion of agricultural production takes place on military farms. Note that because of incomplete data coverage, not every regression in this table actually drops data compared to my baseline specification. For instance, I do not observe a breakdown of GDP into Primary and non-Primary for Jiangsu so the results for these variables 'omitting Jiangsu' restate by baseline results. In general the exclusion of any one province does not substantively change the results. The exclusion of Hebei does increase the size of the standard errors, and for investment in fixed assets the results are no longer significant. Given the large number of counties and wide variation in suitability for cash crops in Hebei this is not entirely surprising.

Table A.8: Omitting Provinces

Omitted Province	(1) Jiangsu	(2) Zhejiang	(3) Jiangxi	(4) Sichuan	(5) Hebei	(6) Shanxi	(7) Guizhou	(8) Gansu	(9) Xinjiang
A. Ln Primary GDP									
Suitability for Cash	0.162***	0.171***	0.164***	0.165***	0.136	0.176***	0.169***	0.118**	0.196***
Crops × 1985	(0.052)	(0.055)	(0.053)	(0.056)	(0.089)	(0.045)	(0.055)	(0.055)	(0.068)
Suitability for Cash	0.236***	0.241***	0.234***	0.238***	0.186*	0.286***	0.253***	0.189**	0.241***
Crops × Post 85	(0.068)	(0.070)	(0.069)	(0.069)	(0.095)	(0.058)	(0.072)	(0.074)	(0.086)
Observations	7993	7169	6784	7819	6088	7567	6812	6917	6795
Counties	561	501	475	549	425	532	481	484	480
B. Ln Non-Primary GDP									
Suitability for Cash	0.039	0.031	0.044	0.040	0.045	0.054	0.051	0.024	0.028
Crops × 1985	(0.031)	(0.034)	(0.032)	(0.034)	(0.047)	(0.033)	(0.034)	(0.034)	(0.036)
Suitability for Cash	0.193***	0.187***	0.196***	0.194***	0.188**	0.218***	0.196***	0.161**	0.205**
Crops × Post 85	(0.069)	(0.071)	(0.070)	(0.070)	(0.079)	(0.069)	(0.073)	(0.080)	(0.081)
Observations	7993	7169	6784	7819	6088	7567	6812	6917	6795
Counties	561	501	475	549	425	532	481	484	480
C. Ln Savings									
Suitability for Cash	0.022	0.012	0.026	0.023	0.016	0.034	0.033	0.005	0.030
Crops × 1985	(0.032)	(0.033)	(0.033)	(0.034)	(0.045)	(0.035)	(0.035)	(0.034)	(0.036)
Suitability for Cash	0.181**	0.175**	0.184**	0.181**	0.169*	0.204***	0.183**	0.147*	0.203**
Crops × Post 85	(0.073)	(0.075)	(0.074)	(0.075)	(0.087)	(0.076)	(0.078)	(0.085)	(0.081)
Observations	5012	5039	4668	5859	3835	5859	5859	5859	4882
Counties	359	364	334	420	284	420	420	420	339
D. Ln Investment in Fixed Assets									
Suitability for Cash	0.061	-0.103	-0.065	-0.065	-0.167	-0.065	-0.050	-0.107	-0.066
Crops × 1985	(0.100)	(0.134)	(0.130)	(0.128)	(0.205)	(0.128)	(0.137)	(0.139)	(0.161)
Suitability for Cash	0.415***	0.285***	0.317***	0.318***	0.153	0.318***	0.334***	0.331***	0.311**
Crops × Post 85	(0.077)	(0.108)	(0.104)	(0.103)	(0.162)	(0.103)	(0.102)	(0.114)	(0.121)
Observations	6286	5811	6223	6639	4630	6639	5495	5582	5807
Counties	511	514	488	572	436	572	494	498	491
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors two-way clustered at the prefecture and province-by-time levels to allow for autocorrelation over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. Interaction terms are dummies for 1985 or years after 1985. Data covers non-municipal counties in Gansu, Guizhou, Hebei, Jiangxi, Xinjiang, Zhejiang and parts of Shanxi and Sichuan for 1965, 1970, 1978, 1985, 1990, 1995, 2000 & 2000-2008.

Appendix B

Appendices to Chapter 3: Family Size and the Demand for Sex Selection: Evidence From China

B.1 Data Appendices

This section provides additional details on data construction not discussed in the chapter.

B.1.1 Construction of Prefectural Level Data from 1982 and 1990 Census microdata.

Both the 1982 and 1990 Population Census microdata include GB codes indicating each households prefecture of residence. The prefecture is the administrative unit between the province and the county. There are around 330 prefectures in China, the average province consists of 11 prefectures and the average prefecture 7-8 counties.

In constructing the set of prefectures I face two issues. First, the prefectural identifiers in the microdata are different to the GiS data provided for the same census and so I must match the microdata to the geographic data. Second the prefectural boundaries—and identifiers—change over time, so I must identify the prefectures with consistent boundaries over time.

To solve the first issue, I manually produced a concordance between the identifiers provided in the microdata and those from the GiS maps of census boundaries provided by University of Michigan China Data Center (2006).[1] For a number of prefectures I was unable to make a match between the census microdata and the GiS boundaries. In the 1982 data these prefectures accounted for around 2% of the population.

To solve the problem of prefectural boundaries changing over time I took the following steps. First, I calculated the centroids for all prefectures in all years. Second, for each year, I count the number of centroids contained within a prefectures polygon for the other year. I then discard all prefecture where this number is not equal to one. I then merge the 1982 and 1990 datasets together and drop all prefectures for which

[1] These maps appear to be identical to those created by the Harvard China Historical GiS Project.

data do not exist for all three years. This eliminates prefectures which were split or merged as well as prefectures with large border changes, however some minor border may changes may remain. The correlation between suitability for cash crops based on 1982 borders with that based on 1990 borders for the sample of counties used is 0.9999, which does not indicate the presence of many large border changes!

After both steps, I am left with a total of 229 usable prefectures, where I am able to observe aggregate variables over areas with consistent boundaries (out of a total of 319 identified in the 1982 census microdata and 347 in the 1990 census microdata). This procedure results in the complete exclusion of prefectures from Shanghai and Hainan, so regressions based on this data have only 27 provinces. As elsewhere, Tibet, Hong Kong and Macau are also excluded from the data.

B.2 Additional Results

This section provides additional details on empirical findings not discussed in the main chapter.

B.2.1 Relationship between marital status, propensity to have begun childrearing, and suitability for cash crops

As discussed in section 3.4.2, the higher fertility observed in counties with faster income growth could, in principle, have been due to earlier marriage and earlier commencement of childrearing. The results in table 3.4, indicated that at least 2/3 of the increase in fertility was on the intensive margin, which we would not expect to be as strongly influenced by early marriage. However, in table B.1, I explore whether suitability for cash crops is associated with the marriage or childrearing propensity.

Using the cross section of women in the 1990 population census, panel A indicates that suitability for cash crops is uncorrelated with the

Table B.1: Probability of Marriage and Age Married

	(1)	(2)	(3)	(4)
Panel A. Never Married Dummy (Women)				
Suitability for Cash	0.005	-0.001	-0.005	-0.004
Crops	(0.007)	(0.005)	(0.004)	(0.003)
Constant	0.379***			
	(0.008)			
N	1527112	1527112	1527108	1955501
Panel B. Never Had A Child Dummy (Women)				
Suitability for Cash	0.011*	0.009*	0.004	0.003
Crops	(0.006)	(0.005)	(0.004)	(0.003)
Constant	0.484***			
	(0.007)			
N	1527112	1527112	1527108	1955501
Panel C. Age of Married Women				
Suitability for Cash	0.094*	-0.046	-0.032	-0.005
Crops	(0.053)	(0.060)	(0.043)	(0.105)
Constant	25.396***			
	(0.074)			
N	946430	946430	946424	1372504
Panel D. Age of Women Who Have Never Had A Child				
Suitability for Cash	0.026	-0.006	-0.010	-0.008
Crops	(0.049)	(0.034)	(0.023)	(0.027)
Constant	20.987***			
	(0.073)			
N	742402	742402	742401	750139
Panel E. Never Married Dummy (Men)				
Suitability for Cash	-0.032***	-0.029***	-0.032***	-0.026***
Crops	(0.008)	(0.007)	(0.007)	(0.006)
Constant	0.532***			
	(0.010)			
N	1610910	1610910	1610908	2078186
Panel F. Age Married Men				
Suitability for Cash	-0.115**	-0.201***	-0.174***	-0.187*
Crops	(0.055)	(0.070)	(0.054)	(0.095)
Constant	25.991***			
	(0.070)			
N	761925	761925	761923	1196832
Province FE		Yes	Yes	Yes
Controls			Yes	Yes
Sample Born	1960-1972	1960-1972	1960-1972	1955-1972

Robust standard errors clustered at province (29) level to allow for autocorrelation of errors over time and space (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). Suitability for cash crops is the (standardised) relative suitability of cash crops compared to grains in the county the mother lives. 'Controls' are a full set of dummies for educational attainment, registration status (to capture migrant status), ethnicity and age (not panels C, D, F). The sample consists of individuals in 1% sample of the 1990 population census bron between 1960- or 1955-1972 as indicated.

propensity to be married amongst young women. Panel B indicates that if anything young women are more likely to be childless (although the estimated coefficients are small). Panels C and D, indicate that there is no relationship between the age of married or childless young women and suitability for cash crops. In the cross section at least, there is no relationship between the age at which women are getting married or starting a family, and my source of variation in incomes. Although it is possible the absence of a cross sectional relationship masks a differential post reform change, the fact that most of the effect on fertility is observed on the intensive margin suggests that changes in the timing of fertility decisions is unlikely to be driving the results.

Interestingly, panels E and F indicate that amongst men there is some change in the timing of marriage. Men in living in counties which enjoyed faster post reform growth in incomes have a slightly higher propensity to be married and appear to get married at a younger age. This is consistent with higher incomes making it easier for young men to accumulate sufficient savings to enter marriage and form a household. However, the estimated effects remain quite small—a one standard deviation increase in suitability is associated with around a two month decline in the average age of married men between 18 and 30—and so are unlikely to have large impacts on virility.

B.3 Additional Tables

Table B.2: Effects on Fertility: Definition of Pre and Post

	Any Birth Dummy		
	(1)	(2)	(3)
Suitability for Cash Crops × 1982-1990	0.033***		
	(0.010)		
Suitability for Cash Crops × 1979-1990		0.031***	
		(0.011)	
Suitability for Cash Crops × 1985-1990			0.026***
			(0.009)
Mother-Year Observations	13.7m	13.7m	13.7m
Mother FE	Yes	Yes	Yes
Province-by-Time FE	Yes	Yes	Yes
Province-by-Mother-Age FE	Yes	Yes	Yes

Robust standard errors clustered at province (29) level to allow for autocorrelation of errors over time and space (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). Suitability for cash crops is the (standardised) relative suitability of cash crops compared to grains in the county the mother lives. The other variable relate to past fertility history. The sample consists of a panel of married women born between 1945 and 1959 and their fertility events for years between 1973 and 1990. The fixed effects allow for province specific paths of fertility by age, as well as province specific trends in overall fertility.

Table B.3: Effects on Sex Ratios: Definition of Pre and Post

	Girl Dummy			
	(1)	(2)	(3)	(4)
SCC × No Brother × Born 1979-1990	0.022***			
	(0.008)			
SCC × No Brother × Born 1982-1990		0.024***		
		(0.008)		
SCC × No Brother × Born 1985-1990			0.028***	0.032***
			(0.008)	(0.010)
Observations	890908	890908	890908	606006
County-by-Birth Year FE	Yes	Yes	Yes	Yes
County-by-No Brother FE	Yes	Yes	Yes	Yes
Province-by-Birth-Year-by-No Brother FE	Yes	Yes	Yes	Yes

Robust standard errors clustered at the provincelevel to allow for autocorrelation of errors over time and space (*** p<0.01, ** p<0.05, * p<0.1). Suitability for cash crops is the (standardised, county average) ratio of the value of output of the best cash crop to the value of output of the best grain crop. No Brothers is a dummy taking a value of 1 indicating that at birth the individual had no male older siblings. Born after 1982-1990 is a dummy indicating that the individual was born after 1981. SCC is my normalised measure of suitability for cash crops. The sample is all individuals born between 1973 and 1990 with one older sibling in the 1% sample of the 1990 Chinese Population Census excluding Hong Kong, Macao and Tibet as well as a small number of individuals which could not be matched to geographic data and a small number of other exclusions discussed in the main text. Column 4 excludes individuals born during the reform years.